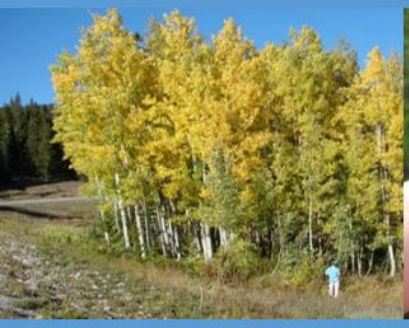


Collaborative Science, Conserving Landscapes

The Wyoming Chapter of The Wildlife Society & the Wyoming Landscape Conservation Initiative 2015 Joint Conference

Lander Convention Center
December 1-3, 2015

Welcome

Welcome to the first Joint Conference between the Wyoming Chapter of The Wildlife Society and the Wyoming Landscape Conservation Initiative. This conference brings together restoration practitioners, resource specialists, researchers and scientists, managers and planners, and students to share ideas about research and restoration and to promote collaborative science and successful conservation of landscapes in the state of Wyoming.

Our conference highlights a special session that addresses Greater Sage-Grouse and Effectiveness of Wyoming's Sage-Grouse Executive Order. We also have four workshops focused on 1) developing leadership skills and training, 2) discussing career opportunities working for and with Industry and other non-governmental agencies, 3) communicating and engaging non-scientific audiences, and 4) an introduction to the R Program.

We also have over 60 oral presentations and 20 poster presentations covering seven themes relevant to both WY-TWS and WLCI. Student presentations will be judged with the top presentation receiving an award.

In addition, the WY-TWS is also sponsoring a quiz bowl, a mentors lunch, an evening social to coincide with poster presentations, and a banquet.

We hope you enjoy this joint conference,

The Conference Committee

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WLCI Coordination Team
USGS Ecosystem Dynamics Branch,
Fort Collins Science Center

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USFWS, Fish & Wildlife Biologist,

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Joe Budd
WLCI STAC
Senior Policy Analyst, Wyoming
Department of Agriculture

Peter E. Godfrey
WLCI STAC
Physical Scientist, BLM Wyoming
State Office

Rachel Nuss
SWaHM Office Manager, Wyoming
Game and Fish Department

Special Session, Workshop, and Session Organizers and Moderators

Special Session: Effectiveness of Wyoming's Sage-Grouse Executive Order

Organizer:

Jeff Beck, Department of Ecosystem Science and Management, UW

Workshop: Wyoming Chapter, The Wildlife Society - 2015 Leadership Training

Instructors:

Tom Ryder, Past President, The Wildlife Society, Deputy Chief, Wildlife Division, WGFD (Retired)
Nicole Cudworth, TWS Leadership Institute Graduate (2011), Wildlife Biologist, WGFD
Tony Mong, TWS Leadership Institute Graduate (2011), Wildlife Biologist, WGFD

Workshop: Careers Industry Biologists: Career Opportunities Working For and With Industry

Organizer:

Julie Lutz, Environmental Engineer Tronox Alkali

Workshop: Communicating and Engaging Non-Scientific Audiences

Facilitators:

Joshua Coursey and Joey Faigl , Muley Fanatic Foundation

Workshop: Program R: a basic introduction (parts I and II)

Instructors:

Jason Carlisle, WY Cooperative Fish & Wildlife Research Unit, U. of Wyoming
Joe Ceradini, WY Cooperative Fish & Wildlife Research Unit, U. of Wyoming
Embere Hall, WY Cooperative Fish & Wildlife Research Unit, U. of Wyoming

Session 1: New Tricks: Methods, Models, & More

Moderators:

Jill Frankforter, USGS Wyoming-Montana Water Science Center
Pat Anderson, USGS/WLCI Coordination, Fort Science Center

Session 2: Mitigating Habitat Loss, Implementing Habitat Success

Moderators:

Rox Hicks, WLCI Coordination Team, STAC, USFWS
Stephanie Anderson, WLCI Coordination Team Lead, BLM, High Desert District

Session 3: Costs of Creature Comforts: Wildlife versus Human Development

Moderator:

Matt Hayes, President-Elect WYTWS, Wyoming Cooperative Fish and Wildlife Research Unit, UW

Session 4: Adapting Management, Revising Policy

Moderators:

Joe Budd, WLCI STAC, Senior Policy Analyst, Wyoming Department of Agriculture
Peter E. Godfrey, WLCI STAC, Physical Scientist, BLM Wyoming State Office

Session 5: Conservation and Research of Threatened Species and Species of Concern

Moderator:

Dan Thompson, Science Committee WYTWS, Large Carnivore Section Supervisor, WGFD

Session 6: Dynamics of sage-grouse populations and sagebrush habitats

Moderators:

Dan Manier WLCI Science Team, USGS Fort Collins Science Center
Tim Assal, WLCI Science Team, USGS Fort Collins Science Center

Session 7: Ungulate Migration, Migration Habitat, and the Green Wave

Moderator:

Bob Lanka, WLCI STAC Committee Chair, Statewide Wildlife and Habitat Management Supervisor, WYGFD

Contents

Conference Agenda

Tuesday, December 1	
8:00 to 8:10	*Introductions and Welcome*. Matthew Hayes, WYTWS President-Elect
8:10 to 8:20	*Welcome Statements*. Wally Johnson, WLCI Executive Chairman
8:20 to 8:40	*Conference Overview*. Pat Anderson, USGS/WLCI Coordination & Zack Bowen, USGS WLCI Science Team
8:40 to 9:00	*Role of Science and Collaboration in WLCI and Wyoming*. Rich Ferrero, USGS Northwest Regional Director
9:00 to 9:20	*BLM Science Strategies & Integration with the Science Community* Robert Boyd, Branch Chief, BLM National Operations Center
9:20 to 9:40	*Keynote Address: Role of Collaboration in Landscape Conservation, Management and Stewardship* Walt Gasson, Trout Unlimited
Break	

New Tricks: Methods, Models & More [Main Room]		**Mitigating Habitat Loss, Implementing Habitat Success [Breakout Room]**	
10:00 to 10:20	GROUNDWATER AND SURFACE-WATER INTERACTION IN THE UPPER GREEN RIVER BASIN **Cheryl A. Eddy-Miller**, Jerrod D. Wheeler, and Ruth M. Law	10:00 to 10:20	RECONNECTING AND RESTORING HABITATS IN THE LOWER ENCAMPMENT RIVER DRAINAGE **Christina E. Barrineau**
10:20 to 10:40	SPATIAL AND TEMPORAL TRENDS OF DROUGHT EFFECTS ON ASPEN FOREST IN SOUTHWESTERN WYOMING **Timothy J. Assal**, Patrick J. Anderson, and Jason Sibold	10:20 to 10:40	EMULATED NATURAL DISTURBANCE AS HABITAT RESTORATION FOR THE WYOMING TOAD (ANAXYRUS BAXTERI) ****James Vance**, Melanie Murphy, Tyler Abbott
10:40 to 11:00	ESTIMATING RESOURCE LIMITATION IN MOOSE USING ENDOCRINE TOOLS ****Brett R. Jesmer**, Jacob R. Goheen, Kevin L. Monteith, and Matthew J. Kauffman	10:40 to 11:00	RE-ESTABLISHMENT OF WYOMING BIG SAGEBRUSH USING CONTAINER GROWN SEEDLINGS ****David C. Balthrop** and Peter D. Stahl

11:00 to 11:20	MICROREFUGIA IN A WARMING WORLD: CRITICAL RESOURCE OR SIMPLE PERK? ****Embere Hall**, Anna Chalfoun, Erik Beever, Anne Loosen	11:00 to 11:20	**FISH PASSAGE IN THE WLCI: BUILDING RESILENCY FOR THE FUTURE** Nick Scribner, Erin Sobel , and Nick Walrath
11:20 to 11:40	MONITORING RIPARIAN FEATURES IN 3D **Samuel E Cox**, D Terrance Booth, John C Likins	11:20 to 11:40	VEGETATION HEALTH AND SPECIES COMPOSITION ON FERRIS MOUNTAIN, INCLUDING THE PLANT RESPONSE FOLLOWING THE 2011 MANAGED WILDFIRE AND 2012 WILDFIRE AND SUBSEQUENT AERIAL TREATMENTS OF IMAZAPIC TO CONTROL CHEATGRASS **Andy Warren**
11:40 to 12:00	MOUNTAIN SHRUB MAPPING USING REMOTELY SENSED DATA, STATISTICAL MODELS AND GROUND-TRUTHING **Geneva Chong**, Catherine Jarnevich, Marie Dematitis, Timothy Assal, Patrick Anderson	11:40 to 12:00	USING SPECIES' TRAITS TO PREDICT SMALL MAMMAL RESPONSES TO INVASIVE PLANTS ****Joseph Ceradini** and Anna Chalfoun
Lunch (on your own)			
		Wildlife Research, Conservation, and Management (part 1) [Breakout Room]	
1:00 to 1:20	APPLICATIONS OF eDNA FOR BIODIVERSITY MONITORING **Melanie Murphy,** Charlotte Gabrielsen, A Elise Sulser, Victoria Zero, Andrew Gygli, Wendy Estes-Zumpf, Rick Henderson, Amy Pocewicz, Teresa Tibbits	1:00 to 1:20	A REVIEW OF SPATIAL AND TEMPORAL PATTERNS IN GOLDEN EAGLE DIETS IN THE WESTERN UNITED STATES, WITH IMPLICATIONS FOR CONSERVATION PLANNING **Geoffrey Bedrosian**, Brian Woodbridge, Gary E. Williams, Kent R. Keller, James Watson, Charles R. Preston
1:20 to 1:40	SUGGESTIONS FOR IMPROVEMENTS TO RESTORATION MONITORING ****Michael Curran,** Peter Stahl	1:20 to 1:40	DO SAGE-GROUSE CORE AREAS PROTECT NON-GAME WILDLIFE OF CONCERN? ****Jason D. Carlisle,** Anna D. Chalfoun, Douglas A. Keinath, Shannon E. Albeke

1:40 to 2:00	DESIGN, METHODS AND PRODUCTS OF THE INTEGRATED MONITORING IN BIRD CONSERVATION REGIONS (IMBCR) PROGRAM **Nick Van Lanen**	1:40 to 2:00	WYOMING'S SPINELESS WILDLIFE: CURRENT STATUS OF RARE INVERTEBRATES IN WYOMING **Lusha Tronstad**
2:00 to 2:20	NATURAL RESOURCES AND ENERGY EXPLORER (NREX): THE NEXT GENERATION OF GIS-BASED PLANNING SUPPORT TOOLS FOR WYOMING'S RESOURCES Philip L. Polzer, Jeffrey D. Hamerlinck, **Teal B. Wyckoff,** Mary Flanderka, and Nephi Cole	2:00 to 2:20	OCCUPANCY OF NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*) IN WYOMING **Ian Abernethy**, Douglas Keinath

Break

WORKSHOPS

Leadership [Breakout Room 1 & 2]	**Careers in Wildlife** [MAIN ROOM]	**R Programming (day 1)** [Breakout Room 3]
3:00 – 5:00	3:00 – 5:00	3:00 – 5:00

DINNER
(on your own)

QUIZ Bowl

6 – 10 pm
Colter Loft/Gannett Grill
126 Main St, Lander, WY
Come early to grab drinks and food! Quiz Bowl will start around 7.

Wednesday, December 2

Presidents Breakfast
07:00 to 08:20
[Breakout Room 1]

	Intersection of Wildlife and Human Development [Main Room]		Wildlife Research, Conservation, and Management (part 2) [Breakout Room]
8:20 to 8:40	UNLOCKING THE RELATIONSHIP BETWEEN IRRIGATED WORKING LANDS, ANTHROPOGENIC DISTRUBANCE AND WILDLIFE HABITAT VALUE IN WYOMING'S DYNAMIC WETLAND LANDSCAPES **Holly Copeland,** Teresa Tibbets, Lindsey Washkoviak, Steve Tessmann, Susan Patla	8:20 to 8:40	DENSITY DEPENDENCE, WHITEBARK PINE, AND VITAL RATES OF YELLOWSTONE GRIZZLY BEARS **Frank T. van Manen,** Mark A. Haroldson, Daniel D. Bjornlie, Michael R. Ebinger, Daniel J. Thompson, Cecily M. Costello, Gary C. White
8:40 to 9:00	INFLUENCE OF OIL AND GAS DEVELOPMENT ON BIG GAME HUNTING SUCCESS IN WYOMING, USA **Monica A. Dorning**, Steven L. Garman, Jay E. Diffendorfer, Darius J. Semmens, Todd J. Hawbaker, and Kenneth J. Bagstad	8:40 to 9:00	BREEDING SUCCESS AND NON-BREEDING SEASON HABITAT USE PATTERNS OF LONG-BILLED CURLEWS IN WESTERN WYOMING **Susan M. Patla,** Jay Carlisle, and Stephanie Coates
9:00 to 9:20	THE EFFECTS OF OIL AND GAS DEVELOPMENT FOR AQUATIC HABITATS **Annika Walters** and Carlin Girard	9:00 to 9:20	ROCKY MOUNTAIN AMPHIBIAN PROJECT: BIOLOGISTS AND CITIZEN SCIENTISTS WORKING TOGETHER TO MONITOR AMPHIBIANS **Wendy Estes-Zumpf**, Zachary Walker, Charlotte Snoberger, Brenna Marsicek
9:20 to 9:40	SIMULATION ASSESSMENT OF FUTURE OIL AND GAS DEVELOPMENT SCENARIOS AND IMPACTS TO PYGMY RABBIT HABITAT **Steven L. Garman** and Stephen S. Germaine	9:20 to 9:40	GOLDEN EAGLE DIET AND PRODUCTIVITY IN RELATION TO FLUCTUATIONS IN PRIMARY PREY ABUNDANCE IN WYOMING'S BIGHORN BASIN **Charles R. Preston**, Richard Jones, and Nathan Horton

Break

			Adapting Management, Revising Policy [Breakout Room]
10:00 to 10:20	DOES OIL AND NATURAL GAS DEVELOPMENT AND HYDROLOGY INTERACT TO AFFECT FISH POPULATION DYNAMICS? **Richard Walker, Carlin Girard, and Annika Walters	10:00 to 10:20	DEER-VEHICLE COLLISIONS IN WYOMING: CHALLENGES AND OPPORTUNITIES **Corinna Riginos**, Morgan Graham, Chauncey Smith, and Melanie Davis
10:20 to 10:40	ON GAS FIELDS AND PYGMY RABBITS: FACTORS EXPLAINING RABBIT PRESENCE AND ABUNDANCE **Steve Germaine**, Sarah Carter, and Drew Ignizio	10:20 to 10:40	EFFECTS OF CHRONIC WASTING DISEASE ON FREE-RANGING DEER POPULATIONS IN WYOMING **Melia DeVivo**, David Edmunds, Matthew J. Kauffman, Justin Binfet, Bryan Richards, Terry Kreeger, Brant Schumaker, and Todd Cornish
10:40 to 11:00	INVESTIGATION OF MERCURY INPUTS AND BIOGEOCHEMICAL CYCLING IN BIGHORN LAKE, BIGHORN CANYON NATIONAL RECREATION AREA, MONTANA, AND WYOMING **Elliott P. Barnhart**, Zachary Eddy and David L. Naftz	10:40 to 11:00	WATER SHORTAGE, CLIMATE CHANGE, AND AGENCY LAND MANAGEMENT **D.T. Booth**, J.C. Likins, and S.E. Cox
11:00 to 11:20	MECHANISMS UNDERLYING EFFECTS OF ENERGY DEVELOPMENT ON WILDLIFE: AN UPDATE ON WLCI SONGBIRD RESEARCH **Anna D. Chalfoun**, Matthew G. Hethcoat, Tracey N. Johnson Lindsey E. Sanders	11:00 to 11:20	THE ELEMENTS OF SUCCESS IN FISH AND WILDLIFE MANAGEMENT: LOOKING BACK AT THE SUCCESSES AND FAILURES OF WILDLIFE CONSERVATION TO GUIDE THE PROFESSION OVER THE NEXT 100 YEARS **Paul Hansen**, Rollie Sparrowe, and Mark Damian Duda
11:20 to 11:40		11:20 to 11:40	POWER POLE DENSITY INFORMS SPATIAL PRIORITIZATION FOR MITIGATING AVIAN ELECTROCUTION James F. Dwyer, Rick E. Harness, Brian D. Gerber, **Gary E. Williams**, Melissa A. Landon, Paul Petersen, Daryl D. Austin, Brian Woodbridge, Todd Lickfett, Duncan Eccleston, and Jason Tack
MENTOR LUNCH 11:40 to 1:00 [Breakout Room 1]			

	1:00 to 1:20	IS THERE A CASE FOR AGE IN UNGULATES? **Kevin L. Monteith**
	1:20 to 1:40	META-ANALYSIS OF WILD HORSE DIET COMPOSITION AND CONFLICT WITH LIVESTOCK AND WILD UNGULATES ON WESTERN RANGELANDS OF NORTH AMERICA **Jeffrey L. Beck**, J. Derek Scasta, and Catherine J Angwin
	1:40 to 2:00	FUNCTIONALITY OF LARGE CARNIVORE RANGE EXPANSION; EMPLOYING FIELD DATA AND MODELING EFFORTS TO EVALUATE MOUNTAIN LION RECOLONIZATION **Dan J. Thompson**, Michelle LaRue, Jonathan A. Jenks, Justin G. Clapp
	2:00 to 2:20	EVALUATING EFFECTS OF HABITAT CONDITION, WEATHER AND PREDATOR DENSITY ON SHIRAS MOOSE DEMOGRAPHY ****Brendan A. Oates**, Jacob R. Goheen, Gary L. Fralick, Kevin L. Monteith, Jerod A. Merkle, Matthew M. Hayes, Daniel R. Stahler, Douglas W. Smith, Sarah Dewey, Steven L. Cain, Michael D. Jimenez, Matthew J. Kauffman
Break		
WORKSHOPS		
Communicating Science to the Public [Main Room]		**R Programming (day 2)** [Breakout Room 3]
2:40 – 5:00		2:40 – 5:00
DINNER (on your own)		
Poster Session/Social 6 – 10 pm Conference Center		

Thursday, December 3			
Ungulate Migration, Migration Habitat, and the Green Wave [Main Room]		**Dynamics of sage-grouse populations and sagebrush habitats** [Breakout Room]	
8:20 to 8:40	THE WYOMING MIGRATION INITIATIVE: ADVANCING THE UNDERSTANDING AND CONSERVATION OF WYOMING'S UNGULATE MIGRATIONS **Matthew J. Kauffman**	8:20 to 8:40	PREDICTION OF ANNUAL ESTIMATED HARVEST OF GREATER SAGE-GROUSE BASED ON SEASON REGULATIONS, SURVEY BIAS, AND HUNTER ACCESS **Jonathan B. Dinkins** and Jeffrey L. Beck
8:40 to 9:00	EVALUATING THE INFLUENCE OF DEVELOPMENT ON MULE DEER MIGRATIONS ****Teal B. Wyckoff**, Matthew J. Kauffman, Shannon E. Albeke, Hall Sawyer, Steven L. Garman	8:40 to 9:00	GREATER SAGE-GROUSE RESPONSE TO GRAZING TIMING AND INTENSITY IN WYOMING **Adrian P. Monroe**, Cameron L. Aldridge, Timothy J. Assal, Kari E. Veblen, David A. Pyke, Michael L. Casazza
9:00 to 9:20	NUTRITIONAL RELATIONSHIPS BETWEEN MULE DEER BEHAVIOR AND HUMAN DISTURBANCE ****Samantha P.H. Dwinnell**, Hall Sawyer, Matthew J. Kauffman, Gary L. Fralick, and Kevin L. Monteith	9:00 to 9:20	INVESTIGATING SAGE-GROUSE POPULATION TRENDS AMID INTENSE ENERGY DEVELOPMENT IN NORTHEAST WYOMING ****Nyssa I. Whitford**, Joseph A. Bishop, Thomas J. Christiansen
9:20 to 9:40	DOES DROUGHT AFFECT THE ABILITY OF MIGRATORY MULE DEER TO SURF THE GREEN WAVE? ****Ellen Aikens**, Kevin Monteith, Jerod Merkle, Geneva Chong, Samantha Dwinnell and Matthew Kauffman	9:20 to 9:40	EFFECTS OF MOWING AND HERBICIDE TREATMENTS ON THE NUTRITIONAL QUALITY OF SAGEBRUSH IN CENTRAL, WYOMING ****Kurt T. Smith,** Naida Rizvic, Jennifer S. Forbey, Jeffrey L. Beck, and Jason R. LeVan
Break			
10:00 to 10:20	STRAIGHT FROM THE MULE DEER'S MOUTH: USING BOTH SATELLITE DATA AND DEER MIGRATION LOCATIONS TO EXPLORE TEMPORAL AND SPATIAL TRENDS IN LANDSCAPE VEGETATION PRODUCTIVITY **Geneva Chong**, Ellen Aikens, Marian Talbert, Jeffrey Morisette, Matthew Kauffman, Timothy Assal, Brian Miller	10:00 to 10:20	MITIGATION BY DESIGN IN WYOMING: MAKING THE CONNECTION BETWEEN WILDLIFE DISTRIBUTION, HABITAT, RESTORATION, AND MITIGATION **Daniel Manier**, Adam Green, Adrian Monroe, Cameron Aldridge and Michael O'Donnell

10:20 to 10:40	THE EXTRA MILE: UNGULATE MIGRATION DISTANCE ALTERS USE OF SEASONAL RANGE AND EXPOSURE TO ANTHROPOGENIC RISK **Hall Sawyer**, Arthur Middleton, Kevin Monteith, and Matthew Hayes	10:20 to 10:40	LONG TERM SAGEBRUSH HABITAT MONITORING ACROSS WLCI, WHAT IS CHANGING AND WHAT DOES IT MEAN? **Collin Homer**, Debbie Meyer, George Xian
10:40 to 11:00	DO LARGE HERBIVORES SURF NDVI-BASED RATE OF GREEN-UP**?** **Jerod A. Merkle**, Matthew J. Kauffman, Kevin L. Monteith, Ellen O. Aikens, Matthew M. Hayes, Kent R. Hersey, Brendan A. Oates, Hall Sawyer, and Brandon M. Scurlock	10:40 to 11:00	A BAYESIAN STATE-SPACE MODEL TO ESTIMATE SAGE-GROUSE TRENDS: IMPACTS OF OIL AND GAS DEVELOPMENT **Adam W. Green**, Cameron L. Aldridge, Michael S. O'Donnell
11:00 to 11:20	PRIORITIZING CONSERVATION VIA PREDICTIVE MODELING OF MIGRATORY HABITAT **Matthew M. Hayes**, Kevin L. Monteith, Hall Sawyer, Holly E. Copeland, and Matthew J. Kauffman	11:00 to 11:20	MULTI-SCALE STATEWIDE WYOMING GREATER SAGE-GROUSE POPULATION VIABILITY ANALYSIS **David R. Edmunds**, Michael S. O'Donnell, Adrian P. Monroe, and Cameron L. Aldridge
Lunch (on your own)			
Sage Grouse Special Session 1:00 to 4:00 [Main Room]			
WLCI Closing Remarks 4:00 to 4:15			
WYTWS Banquet 5-10 Main Room			

Speaker Abstracts

(Presenting author underlined, student presentations noted with an asterisk)

Session 1: New Tricks: Methods, Models, & More

Management and conservation of Wyoming's valuable natural resources require a thorough understanding of a constantly changing landscape. In this session, we explore new methods and tools to collect and analyze scientific data, including new laboratory capabilities and enhanced temporal and spatial analytical techniques to provide a landscape-level understanding of emerging issues. These presentations emphasize the use of these tools to improve research and operations activities, contributing to responsible resource development and management decisions by Federal, State and local governments, academia, and the private sector.

GROUNDWATER AND SURFACE-WATER INTERACTION IN THE UPPER GREEN RIVER BASIN

Cheryl A. Eddy-Miller[1], Jerrod D. Wheeler[2], and Ruth M. Law[2]

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[2]U.S.Geological Survey, Wyoming-Montana Water Science Center, 1225 Market Street, Riverton, WY, 82501, USA

The upper Green River Basin in southwestern Wyoming provides important habitat for a variety of aquatic and terrestrial species, as well as supporting multiple land uses including energy extraction, agriculture, and tourism. Groundwater and surface-water resources of this semi-arid basin are critical to both wildlife and human activities. Understanding the interaction between streams and nearby groundwater in unconsolidated, shallow aquifers is an important component for describing stream dynamics. In particular, groundwater contribution to streamflow can moderate stream temperature during the summer and provide a source of water during winter in the form of base flow. The USGS is using new methods for determining groundwater and surface-water interaction by installing shallow wells on both stream banks at two existing, long-term streamgages in the upper Green River Basin. These sites, located on the New Fork River near Big Piney, Wyoming, and on the Green River near LaBarge, Wyoming, are being utilized to understand the dynamics of the groundwater and surface-water system in that part of the Basin. Water elevation and temperature data from both the wells and streams are being used to determine when the stream may be losing water to or gaining water from groundwater. These data will be input into a two-dimensional model to estimate the volume of water loss or gain to the stream at that location. Additionally, geohydrologic analysis of the northern Green River structural basin shows groundwater in select bedrock units that underlie the shallow aquifers in some areas are under pressure. Water from wells completed this bedrock can often flow without a pump, and a flowing (artesian) well was drilled near the New Fork River streamgage during August, 2015. Data from the flowing well will be used to describe potential groundwater flow from the deeper, pressurized bedrock into the shallow aquifers and subsequently into area streams.

SPATIAL AND TEMPORAL TRENDS OF DROUGHT EFFECTS ON ASPEN FOREST IN SOUTHWESTERN WYOMING

Timothy J. Assal[1], Patrick J. Anderson[1], and Jason Sibold[2]

[1]U.S. Geological Survey (USGS), Fort Collins Science Center, 2150 Centre Avenue, Fort Collins, CO 80526 USA Email: assalt@usgs.gov
[2]Department of Anthropology, Colorado State University, 1787 Campus Delivery, Fort Collins, CO 80523 USA

Drought-induced forest mortality has been reported in western North America over the last decade. Of particular concern is decline in aspen forest, which provides important habitat for many wildlife species and domestic livestock. Understanding patterns of mortality and forest response to severe drought is important to resource managers, given the frequency of these events are expected to increase in the future. Vegetation indices derived from remotely sensed data can be used to analyze forest condition over large areas and over long time periods. We analyzed a 22-year (1985-2012) time series of satellite data to determine changes in forest that experienced a relatively dry period since 2000, punctuated by two years of extreme drought. We modelled the relationship between satellite-derived productivity and field data; then applied the model to the long-term data series to uncover the location, direction, and timing of change. The Normalized Difference Moisture Index (NDMI) had the strongest correlation with plant area index ($R^2 = 0.64$) and canopy gap fraction ($R^2 = 0.65$). Trends were not consistent with respect to forest type or topography, as northern aspects were most likely to exhibit a negative trend. During the study period, over twice as much aspen forest (16.5%) experienced a significant ($p < 0.05$) negative trend, compared to a positive trend (7.1%). Field plots with a negative trend had a lower live density, and higher amounts of standing dead and down trees compared to plots with no trend. Our analysis identifies spatially explicit patterns of long-term trends anchored with ground-based evidence to highlight areas of forest that are resistant, persistent, or vulnerable to severe drought. The results provide a long-term perspective on forest condition in this area and can be used to inform management actions and monitoring at local scales.

ESTIMATING RESOURCE LIMITATION IN MOOSE USING ENDOCRINE TOOLS

Brett R. Jesmer[1,2]*, Jacob R. Goheen[1], Kevin L. Monteith[1,2], and Matthew J. Kauffman[1,3]

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[2]Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, USA
[3]United States Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, USA

The success of many management efforts rest on understanding how energy availability affects population performance. Because population-level energy limitations signal that a population is near its carrying capacity, methods for estimating energy-performance relationships are needed. To meet this need, endocrinology has recently emerged as a popular tool for estimating energy-performance relationships. Endocrine markers such as glucocorticoids (GC) and triiodothryonine (T3) reflect both energy reserves and energy intake in small-bodied animals and in animals within controlled laboratory conditions. It is unclear, however, whether these endocrine markers translate to energy reserves and energy intake for large, free-ranging animals that possess greater fasting endurance and the ability to adjust their foraging behavior in response to energy deficits. We investigated relationships among endocrine markers and metrics of energy reserves and energy intake in free-ranging moose (*Alces alces*). T3 increased as energy reserves declined, a pattern opposite to predictions derived from animals in controlled laboratory conditions. GC was poorly

associated with energy reserves, but increased predictably with increased energy intake, thus supporting a previously posited anti-stress hypothesis. The directionality of these relationships indicate moose forage in a state-dependent manner, where individuals with few reserves have greater energy intake than individuals with ample reserves. It is often assumed that GC and T3-energy relationships developed in the lab translate well to free-ranging populations, but our results indicate that we need to rethink how we apply endocrine tools in the management of big game herds

MICROREFUGIA IN A WARMING WORLD: CRITICAL RESOURCE OR SIMPLE PERK?

Embere Hall[1]*, Anna Chalfoun[2], Erik Beever[3], Anne Loosen[4]

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Rapid climate change affects nearly all biomes, causing notable shifts in phenology, community ecology and extinction dynamics. Favorable microclimates may buffer organisms against rapid change, thereby allowing time for populations to adapt. The degree to which microclimates facilitate the persistence of climate-sensitive species, however, is largely an open question. We addressed whether the importance of favorable microclimates was context-dependent in mammalian thermal specialists, using the American pika (*Ochotona princeps*) as a model organism. We tested four hypotheses about the relationship between microclimates and pika occurrence: 1) Local habitat hypothesis; 2) Subsurface microrefugia hypothesis; 3) Surface temperature hypothesis; and 4) Context-dependent hypothesis. We examined pika occurrence at 146 sites arranged along a gradient of elevation. Site characteristics such as slope, aspect, and forage availability were measured at each site. We deployed 40 pairs of temperature loggers at a subset of points to quantify how much the subterranean environment moderated surface temperatures. Relative support for competing hypotheses was quantified using logistic-regression models in an AICc framework. We found unequivocal support for the subsurface microrefugia hypothesis. Pikas were more likely to occur at sites where the subsurface environment substantially moderated surface temperatures. Microrefugium (surface temperature – subsurface temperature) was the single strongest predictor of pika occurrence, independent of other biotic characteristics. By buffering ambient temperatures, microrefugia likely influence where temperature-limited animals can persist in rapidly warming environments. As climate change continues to manifest, efforts to understand the changing dynamics of animal-habitat relationships will be enhanced by considering both the availability and quality of microrefugia.

MONITORING RIPARIAN FEATURES IN 3D

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Stereo aerial imagery has long been used to measure 3D terrain for products like topographic maps. Structure-from-Motion (SfM) is the process of recreating an object's three-dimensional structure from a series of stereo images acquired from a moving camera and is useful for both measurements

and 3D visualization. Here, through three case studies involving riparian habitat monitoring, we describe the application of stereo imagery to create SfM terrain surfaces from digital images acquired using handheld cameras. Using these terrain models, we were able to measure surface roughness due to hummocks, soil volume loss from headcuts, and elevation profiles that illustrate channel incision and floodplain connectivity. We conclude that SfM terrain models are useful for quantitative monitoring of riparian features, and have the further benefit of providing a permanent, 3D representation of the resource at a point in time.

MOUNTAIN SHRUB MAPPING USING REMOTELY SENSED DATA, STATISTICAL MODELS AND GROUND-TRUTHING

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Traditional mapping is based on observation of existing vegetation – either current, what was there in the past (historical) or what is expected there based on understanding of the system based on previous experience (historical). Given current analysis capacity, we wanted to combine observation of existing vegetation with spatial statistical modeling in an attempt to develop a probabilistic map that could be improved through iterations with ground-truth sampling. Our objective was to develop a full-coverage map of the probability of occurrence of mountain shrub communities in the Wyoming Landscape Conservation Initiative area. Potential mountain shrub predictor layers included topographic and remotely sensed variables. Topographic features were elevation, slope, eastness, and solar radiation index. The remotely sensed variable was the normalized difference vegetation index (NDVI) calculated from SPOT (Satellite Pour l'Observation de la Terre - France) imagery from 19 June 2007 and 4 August 2012. Models were tested using field observations. Three of four models tested had reasonable results: generalized linear models (GLM), multivariate adaptive regression splines (MARS), and random forest (RF). Slope was the dominant predictive variable with NDVI in second in all models. Vegetation communities that occur in small, isolated patches or are structurally similar to different communities around them, such as mountain shrub communities in southwest Wyoming, are difficult to map using traditional methods. This work demonstrates an alternative approach to vegetation mapping that could be applied in other areas with similar situations.

APPLICATIONS OF eDNA FOR BIODIVERSITY MONITORING

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Environmental DNA (eDNA), shed DNA in the environment, is an emerging technique that can be leveraged to monitor biodiversity to meet wildlife management goals. Aquatic eDNA is particularly useful for monitoring amphibian, fish and invertebrate organisms. As a technique, eDNA is extremely reliable, detects presence for less than 3 weeks under tested conditions, and had higher detection rates than visual surveys. To introduce eDNA to wildlife managers and researchers, we

will present a background on how eDNA works, protocols for eDNA collection, and relative costs. We will present a set of case studies using visual DNA: development of eDNA quantitative PCR, amphibian detection in plains systems, amphibian detection in forested systems, relating fish presence with amphibian presence (both using eDNA methods) and potential for eDNA for water quality monitoring. We are able to detect amphibians with high probability of detection, particularly when there was evidence of breeding. In addition, we find that chorus frogs are less likely to occur with the presence of fish. In addition, identification of macroinvertebrates for water quality monitoring is promising. We find the eDNA methods are highly reliable for most situations, but certainly not a substitution for visual surveys. We discuss under what conditions eDNA surveys may be most useful to meet research and management goals.

SUGGESTIONS FOR IMPROVEMENTS TO RESTORATION MONITORING

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As with any type of project, monitoring is critical to track progress, evaluate success, identify problems, and make informed decisions for future management. Additionally, for projects to be successfully managed, a clear definition of success is necessary. On BLM lands in Wyoming, all oil and gas well pads undergoing reclamation are compared to an undisturbed reference site, which is often defined by a single 100 m transect. In a heterogeneous landscape, a single 100 m reference transect fails to capture variability or depict an adequate representation of a reference area. Likewise, a single transect on a site under reclamation may fail give an accurate representation of the reclamation site as a whole. In most cases, field technicians sample restoration sites and reference areas by selecting locations they believe to be most representative of an area, which should be avoided because it is subject to observer bias. Since sampling is representative and monitoring techniques vary between years, analyzing vegetative trends is difficult because reference sites are used as measuring sticks for success our ability to define success and set restoration targets is limited by inconsistencies in monitoring and may vary greatly from year to year. In order to evaluate vegetative trends, site stability and self- sustainability, long-term monitoring plans should be incorporated into overall reclamation plans. A sound monitoring plan must be unbiased, statistically reliable, repeatable, and economical. Due to the increasing demand for vegetation monitoring, sampling techniques should strive to become more cost- efficient and information-rich than in the past. While there are pros and cons to different vegetation sampling techniques, many studies have shown significant differences in results when multiple methods are used. Therefore, a long-term monitoring plan should incorporate standard techniques and permanent sampling areas to identify trends and evaluate habitat quality, site stability, resiliency, and self-sustainability. This talk will discuss strengths and weaknesses associated with different monitoring methodologies and make suggestions on improvement.

DESIGN, METHODS AND PRODUCTS OF THE INTEGRATED MONITORING IN BIRD CONSERVATION REGIONS (IMBCR) PROGRAM

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In 2007, the North American Bird Conservation Initiative (NABCI) monitoring sub-committee developed a report 'Opportunities for Improving Avian Monitoring' (NABCI 2007). This report outlined goals and recommendations to further improve avian monitoring programs including: using more rigorous statistical methodology, integrating monitoring programs, and making data and results widely accessible to land managers and the public. The Bird Conservancy of the Rockies (formerly the Rocky Mountain Bird Observatory), with the help of numerous partners, has developed and implemented an avian monitoring program spanning all or portions of 13 states named Integrated Monitoring in Bird Conservation Regions (IMBCR). The IMBCR program is well suited to address conservation issues and data needs identified by NABCI in their 2007 report including (1) determine status and trends; (2) inform management and policies to achieve conservation; (3) determine causes of population change; (4) evaluate conservation efforts; (5) set population objectives and priorities; and (6) inform conservation design. Continued monitoring under the IMBCR program will allow managers to detect trends in density and occupancy estimates over time as well as provide the raw data needed to develop tools to inform management on what to do and where to do it. Information gathered through the IMBCR program is made accessible to program partners and the public through the Rocky Mountain Avian Data Center (RMADC); a high quality, internet-accessible database. The RMADC is a regional node to the Avian Knowledge Network and serves as a "one stop shop" for accessing datasheets, protocols, reports, population estimates, and raw count data.

NATURAL RESOURCES AND ENERGY EXPLORER (NREX): THE NEXT GENERATION OF GIS-BASED PLANNING SUPPORT TOOLS FOR WYOMING'S RESOURCES

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The Natural Resources and Energy Explorer (NREX) is an online geographic information system (GIS)-based, pre-planning support tool. The application enables the discovery and assessment of energy, wildlife, environmental, cultural, socioeconomic, and infrastructure assets for small user-defined areas of interest. Governor Mead's Wyoming Energy Strategy outlines the need for geospatial tools to facilitate planning, siting, and analysis for energy development and natural resource management. Developed in response to this need, the NREX application advances the Energy Atlas concept within the Wyoming Energy Strategy by providing open access to credible, public geographic information to support place-based decision making based on interpretation of existing conditions. With the advancement of technology and data reliability, NREX is being built using innovative technology and incorporates web-based data services accessed directly from partner agencies. Data includes information from relevant state and federal agencies, including the Wyoming Game and Fish Department, Wyoming Department of Environmental Quality, and the US Fish and Wildlife Service. NREX will ultimately replace the Wyoming Interagency Spatial Database & Online Management System (WISDOM) in 2016.

Session 2: Mitigating Habitat Loss, Implementing Habitat Success

Habitat loss, mitigation, and implementing habitat improvement activities are common terms nowadays as we see declining abundance and changes in the distribution of Wyoming's plant and wildlife species. Federal, State, non-profit organizations, industry, and a recent Presidential Memo, have recognized the need for mitigation policies. Habitat mitigation helps preserve, protect, restore, and maintain the habitat which is ecologically rich. It also involves protecting and preserving species on the landscape in order to prevent their extinction, their reduction in range, and their fragmentation. This session explores how researchers, biologists, agencies, and other partnerships, are implementing conservation efforts to evaluate successful on- and off-site habitat improvement techniques.

RECONNECTING AND RESTORING HABITATS IN THE LOWER ENCAMPMENT RIVER DRAINAGE

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The Encampment River flows north from the Continental Divide in Colorado into the Sierra Madre Range in southeastern Wyoming. As the river exits the mountains, it flows through a wide valley dominated by irrigated hay meadows and cottonwood galleries. Within this lower segment, the Encampment River is characterized by unstable reaches with accelerated bank erosion, channel degradation, and aggradation, and poor connections with floodplain habitats. The legacy effects of tie drives, mining, channel dredging, and land use have led to the present-day channel and riparian habitat conditions. Today, the effects of beetle kill in forested headwaters, climatic extremes, and altered stream flows exacerbate channel instability. In addition, concrete and cobble push-up dam diversions limit seasonal wild trout movements in the lower watershed. Over the last 5 years, the Wyoming Game and Fish Department, Trout Unlimited, and Saratoga-Encampment-Rawlins Conservation District have partnered with the Wyoming Landscape Conservation Initiative and many other partners to lead concentrated efforts for reconnecting and restoring stream habitat, riparian corridors, and fish passage throughout the lower watershed. To date, the partnership has restored over one mile of river and riparian corridor and replaced two cobble push-up dams with fish-friendly diversion structures. Over the next five years, the partners aim to restore two additional river miles, replace two cobble push-up dams, and create fish passage at a concrete diversion dam. These efforts will reconnect habitats for wild trout, and further strengthen relationships with local businesses, water users, landowners, and anglers.

FISH PASSAGE IN THE WLCI: BUILDING RESILENCY FOR THE FUTURE

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Over the past century our western rivers have seen many alterations that have impacted fish and wildlife, stream function, and riparian habitat. Irrigation has been one of the primary perturbations to our stream systems with the construction of instream diversions to deliver water for both agricultural and municipal purposes. In many instances, instream diversions block natural movement of fish, cause entrainment in irrigation canals, and can disrupt channel morphology that leads to stream degradation. In addition, thousands of road crossings exist that impact natural fish movements and healthy stream function as well. To address these issues, Wyoming Game and Fish (WGF) officially began a fish passage program in 2009. Much of the work to date has focused on

inventory of irrigation diversions and road crossings, prioritizing watersheds for work, developing partnerships with organizations such as Trout Unlimited, and delving into various projects to improve passage and reduce entrainment. Efforts are underway to increase the reach of this program through the Wyoming Water Strategy that was released by the Governor's office in January 2015. Fish passage was 1 of 10 initiatives identified in that strategy to improve Wyoming's water resources for the future. A great deal of passage work has already occurred in the Wyoming Landscape Conservation Initiative (WLCI) boundary where efforts have focused on native species such as Colorado and Bonneville cutthroat trout, bluehead sucker, flannelmouth sucker, and roundtail chub. Projects have included removal and construction of barriers, installation of fish screens, and changes in water use through multiple partnerships. Reconnecting streams is vital for the future health of our fisheries and watersheds that will improve the resiliency of these systems in light of more frequent weather extremes. Without such work, we risk the loss of native species and further degradation of our water resources.

VEGETATION HEALTH AND SPECIES COMPOSITION ON FERRIS MOUNTAIN, INCLUDING THE PLANT RESPONSE FOLLOWING THE 2011 MANAGED WILDFIRE AND 2012 WILDFIRE AND SUBSEQUENT AERIAL TREATMENTS OF IMAZAPIC TO CONTROL CHEATGRASS

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Ferris Mountain is a small mountain range comprising about 30,000 acres, located between Casper and Rawlins, Wyoming. Prior to 2011, it was dominated by conifers, including Douglas' and subalpine fir, limber and lodgepole pine, Engelmann spruce, and Rocky Mountain juniper. Although the last major wildfire (circa 1940) had evolved into healthy stands of lodgepole pine, most other conifers were inflicted with insects and disease, including mountain pine beetle, mistletoe, and white pine blister rust. The blister rust was particularly apparent in limber pine, affecting even small young trees. Aspen and riparian habitat were largely encroached with conifers, and eighty year old photos showed conifer expansion into upland shrublands, with shrub species primarily comprised of mountain big sagebrush, Wyoming three-tip sagebrush, and black sagebrush, with scattered areas supporting bitterbrush and chokecherry. A managed wildfire in October 2011 resulted in 1400 acres burned, and a wildfire in August 2012 burned an additional 8,600 acres. Photos and 30 transects were established, and browse quality evaluated. Studies were established to monitor vegetation response, to help determine when livestock grazing could occur, to meet Greater Sage-Grouse core area policy, and to incorporate findings into future fire treatments on Ferris Mountain. Initial fire response was dominated by early successional species, such as evergreen ceanothus, ground smoke, and wild hollyhock, and re-sprouting species that include snowberry, chokecherry, aspen, Wyoming three-tip sage, bluebells, bluebunch wheatgrass, and king-spike fescue. Species negatively impacted (in addition to conifers) were bitterbrush, black sagebrush, and Idaho fescue. Areas with higher potential for cheatgrass expansion (2,000 acres) were aerially treated with Imazapic in the fall of 2012 and 2014. Cheatgrass was reduced or non-existent, while native perennial species grew and expanded, with a reduction of annual forb species. Evergreen ceanothus response post-fire had more than double the crude protein compared to other shrub species.

RE-ESTABLISHMENT OF WYOMING BIG SAGEBRUSH USING CONTAINER GROWN SEEDLINGS

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Wyoming big sagebrush (Artemisia tridentata ssp. wyomingensis) has declined in distribution and abundance over the past 50 years due to ecological and anthropogenic landscape alterations such as wildfire, invasive species, eradication, energy development, and agricultural conversion. This decline has resulted in significant amounts of historical Greater Sage-Grouse habitat left unsuitable for the bird's survival requirements and in need of restoration. The typical method of broadcast seeding has proven difficult in areas with already established vegetation, giving the need to implement new restoration techniques. This study attempts to develop an effective method for transplanting Wyoming big sagebrush seedlings propagated from locally adapted seed and soil that will maximize the amount of soil moisture available to them through snow catchment fencing, fabric mulch, and seedling planting density. 648 sagebrush seedlings were planted in the spring of 2014 onto a 2 year old burn site using a randomized complete block design. Preliminary results show that the use of polypropylene fabric mulch to eliminate interspecific competition and retain soil moisture significantly increases the growth and survival rate of transplanted seedlings. Management implications for this method include planting shrub islands on burn areas in order to reintroduce a seed source or planting into critical habitat areas where sagebrush has been lost or damaged.

USING SPECIES' TRAITS TO PREDICT SMALL MAMMAL RESPONSES TO INVASIVE PLANTS

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Invasive species threaten biodiversity worldwide and are considered the most significant conservation threat after habitat loss and fragmentation. Invasive plants can have direct and indirect effects on wildlife by dramatically simplifying plant community composition and structure. Small mammals are an integral component of many ecosystems, however, the effects of invasive plants on small mammals are poorly understood. This study addresses a critical information need by determining how small mammal occupancy, abundance, survival, and richness are altered by cheatgrass (*Bromus tectorum*), a common invasive plant in North America. In 2013 and 2014, we trapped small mammals on 16 sites across a gradient of cheatgrass cover in Thunder Basin National Grassland, WY. We tested the predictive ability of 3 focal species traits and found the effect of cheatgrass on the probability of occupancy varied with a species' habitat association but not with diet preference or locomotion style. In our species- specific analysis, cheatgrass had a negative effect on pocket mice (*Perognathus* spp.) occupancy, primarily open habitat species. By contrast, occupancy for harvest mice (*Reithrodontomys* spp.), closed habitat species, was positively correlated with cheatgrass. There was no effect of cheatgrass on occupancy for the Ord's kangaroo rat (*Dipodomys ordii*) or the 13-lined ground squirrel (*Spermophilus tridecemlineatus*). Cheatgrass had a positive, neutral, and negative affect on deer mice (*Peromyscus maniculatus*) depending on the metric. Finally, there was no effect of cheatgrass on species richness; however, the occupancy results suggest that small mammal community composition may shift as cheatgrass cover increases. Species' traits partly predicted small mammal responses to cheatgrass, suggesting that a focal traits framework will help managers prioritize species based on their vulnerability to a specific habitat alteration, such as invasive plants.

EMULATED NATURAL DISTURBANCE AS HABITAT RESTORATION FOR THE WYOMING TOAD (*ANAXYRUS BAXTERI*)

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The Wyoming Toad was once abundant throughout the Laramie Basin but, after declining rapidly, is now considered extinct in the wild. A population at Mortenson Lake National Wildlife Refuge, maintained by the release of captive-bred individuals, is one of the only known extant populations. Habitat alteration and disease are thought to be two causes of the Wyoming toad's decline. Open riparian areas have been shown to be important for young individuals, likely facilitating growth, and possibly limiting disease. In the absence of disturbance, however, these open areas quickly become overgrown. We raised recently metamorphosed Wyoming toads in enclosures in areas around Mortenson Lake where vegetation was treated with either prescribed fire or cattle grazing. Toads were measured (mass and length) every 4 to 6 days to determine growth rate and upon release from the enclosure to determine final size. We found that toads raised in areas treated with fire had greater length and mass than toads raised in untreated vegetation. Toads in vegetation treated with cattle grazing were lighter than toads in vegetation that was not grazed; length was not significantly different between grazed and ungrazed areas. These results indicate that fire could be used as habitat restoration in areas managed for Wyoming toads.

Session 3. Costs of Creature Comforts: Wildlife versus Human Development

As human expansion and development continue across the west, so do conflicts between wildlife and humans. Understanding the impacts that a range of human activity has on wildlife is crucial to helping mitigate those impacts. At the same, our demand for things like energy is growing; a balance must be found between human needs, multiple land use needs and conservation of habitat for wildlife species. In this session, we will explore a myriad of ways in which anthropogenic activities are influencing natural systems throughout Wyoming.

MECHANISMS UNDERLYING EFFECTS OF ENERGY DEVELOPMENT ON WILDLIFE: AN UPDATE ON WLCI SONGBIRD RESEARCH

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The WLCI songbird project has provided a rare opportunity to investigate the mechanisms underlying wildlife responses to energy development in a rigorous and spatially and temporally-replicated manner. Extraction of energy resources is a still-growing form of human-induced rapid environmental change in Wyoming and globally, and effective understanding of wildlife effects and mitigation strategies rests not only on *what* effects are occurring, but also *how* and *why*. Responses of the three sagebrush-obligate passerine birds (Brewer's sparrow, *Spizella breweri*; sagebrush sparrow, *Artemisiospiza nevadensis*; and sage thrasher, *Oreoscoptes montanus*) that nest in the WLCI area are particularly important because, similar to the greater sage-grouse, all three are species of concern in Wyoming and declining throughout much of their range. The first phase of the project (2008-2009) demonstrated decreased abundance of two of the three species with increased natural gas well density. Because abundance can be a misleading indicator of habitat quality, however, we also assessed nest survival, which decreased with well density and proximity to the nearest well pad for all species. The vast majority of nest losses were due to nest predation. In Phase II (2011-2012), we deployed infrared video camera systems at nests and learned that rodents (including deer mice, *Peromyscus maniculatus*) were the most important nest predators, and that their relative activity increased with surrounding habitat loss due to natural gas development. Rodent activity, moreover, was inversely related to nest survival. Our current focus (2014) is to test alternative hypotheses for why natural gas development appears to augment local populations of rodent nest predators. In the aggregate, natural gas fields in western Wyoming appear to be functioning as ecological traps for sagebrush songbirds, as birds are settling equally across sites, yet are experiencing decreased reproductive fitness in areas with more surrounding energy development.

UNLOCKING THE RELATIONSHIP BETWEEN IRRIGATED WORKING LANDS, ANTHROPOGENIC DISTRUBANCE AND WILDLIFE HABITAT VALUE IN WYOMING'S DYNAMIC WETLAND LANDSCAPES

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Water management in western rangelands is intrinsically connected to a variety of biologically productive wetland habitats. Sustainability of traditional flood-irrigated rangeland and the biologically rich habitats they provide is at risk as pressure increases on the current water system to meet increasing domestic and industrial demands. Using a statistically valid, field based approach, we modeled wetland conditions and wildlife habitat value for three Wyoming basins. We found that levels of anthropogenic disturbance and hydrologic modification varied across basins as well as among differing wetland types. We piloted a tool to measure predicted avian richness and habitat suitability for sampled wetlands. Major changes in land use, irrigation practices, and on-going climate change will likely have widespread implications to wetlands. For example, in the Upper Green river basin results suggest that 40% of wet meadow wetlands are created or supported by irrigation; conversion to pivot irrigation could potentially affect an estimated 50,000 wetland acres and the wildlife habitat they provide. Our results have relevance for gaining a more holistic understanding of wetland systems that relates current patterns of disturbance and hydrologic modification to habitat value for wildlife. These results will support better decision-making for wetland enhancement, conservation, and restoration.

INFLUENCE OF OIL AND GAS DEVELOPMENT ON BIG GAME HUNTING SUCCESS IN WYOMING, USA

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Development from extracting oil and gas resources can have unintended impacts on multiple ecosystem functions, with cascading effects on wildlife, ecosystem services, and local economies. Big game hunting opportunities may be closely tied to these effects, but empirical analyses of the impacts of oil and gas development on hunting are scarce. In this study, we examined spatial and temporal trends in hunting success and their relationships to oil and gas development density. We focused on hunting success within all hunt areas for three big game species in Wyoming from 2008 to 2014: *Cervus canadensis* (elk), *Odocoileus hemionus* (mule deer), and *Antilocapra americana* (pronghorn). Using 'harvest per hunter day' as a response, we compared linear mixed-effects models for each species that included either total well density (all wells constructed up to the year of record) or active well density (only those wells currently producing oil/gas in that year) as the key predictor variable. The models also accounted for the fixed effects of road density, the proportion of the area that is public land unrestricted to hunters, the proportion of the area that is forested, the year of observation, and the average game population density, as well as random variation among hunt areas nested within associated game herd units. The presence of oil and gas wells had a positive influence on hunting success for elk and mule deer, with no overall influence on pronghorn, though effects varied depending on the animal's life stage and sex. Models that included active wells outperformed those that included the cumulative total. Changes in hunting success as a result of oil and gas development could have subsequent impacts on hunter satisfaction and game populations, issues relevant to both hunters and wildlife managers.

SIMULATION ASSESSMENT OF FUTURE OIL AND GAS DEVELOPMENT SCENARIOS AND IMPACTS TO PYGMY RABBIT HABITAT

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In the sagebrush rangeland of southwestern (SW) Wyoming, foreseeable oil and gas development has the potential to degrade and fragment habitat, and elevate risks to resident populations of sagebrush-obligate species. Advances in drilling technologies such as directional and horizontal well bores, however, can help to minimize undesirable impacts while meeting future energy-production demand. In this study, we used a unique energy-footprint simulator to model future build-out designs that varied in numbers of vertical, directional, and horizontal wells and determined potential impacts of designs to pygmy rabbit (*Brachylagus idahoensis*) habitat. Using the footprint simulator, we spatially modeled future (30 years) wells, pads, and roads in oil and gas project areas in SW Wyoming based on proposed and pending development build-out designs. We simulated a series of alternative design scenarios that successively increased the number of directional and horizontal wells, where geologically feasible, for the same targeted level of energy production. Scenarios used the same number of proposed well numbers but reduced the number of well pads (multi-well pads, directional drilling), or reduced both the number of wells and well pads (horizontal drilling). We scored scenario impacts on pygmy rabbits using an empirically derived model that estimates habitat-occupancy probability given the amount of pad and road surface disturbance within 1 km of suitable habitat. Results illustrate the potential to reduce impacts to pygmy rabbits with increasing use of directional and horizontal drilling. On average, for every reduction of 100 pads there was a 170 ha decrease in total surface disturbance and a 100 ha increase in the amount of rabbit habitat with a probability of occupancy >0.5. Patch sizes of rabbit habitat with >0.5 probability of occupancy also increased with decreasing pad numbers. Overall, results illustrate the ecological benefits of employing directional and horizontal drilling technologies in future resource recovery.

ON GAS FIELDS AND PYGMY RABBITS: FACTORS EXPLAINING RABBIT PRESENCE AND ABUNDANCE

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Gas fields now cover more than 2,300 mi^2 of land in southwestern Wyoming. Gas fields fragment sagebrush habitats by converting native vegetation to roads, well pads, and utility corridors. Pygmy rabbits are a sagebrush-obligate species of greatest conservation need, but little information exists describing the relationship between gas fields and pygmy rabbits. We surveyed 120 plots on four major Wyoming gas fields (Creston/Atlantic Rim, Jonah, Moxa Arch, Pinedale Anticline Project Area) during 2011-2013, measured the amount of shrubsteppe vegetation and each disturbance element present (e.g., roads, well pads, buried utility corridors) within 1 km of each plot using ArcGIS and 2012 NAIP imagery, then modeled the relationship between gas field elements and pygmy rabbit presence and abundance. Well pads, adjacent disturbance, well pad spur roads, and buried utility corridors comprised the majority of the disturbance present (4% of total area on Creston/Atlantic Rim – 12% on Jonah). Rabbit presence was lower on the Jonah field (16% of plots) than the other three gas fields (52-76% of plots). Using logistic regression and accounting for

variation among years and gas fields, the most parsimonious presence/absence model contained the variables buried utilities (negative association), a variable derived by pooling well pads, associated disturbance, and associated spur roads (negative association), and residual shrub cover (positive association). We then used boosted regression trees to analyze an index of abundance (number of active burrows) in plots where rabbits were present. Abundance varied among gas fields (mean = 5.4 burrows/plot at Creston/Atlantic Rim versus ~1.0 burrow/plot on the other gas fields), and that buried utilities, well pads, adjacent disturbance, and associated spur roads had a strong negative relationship with abundance in one or both modeled years. Conversion of shrubsteppe vegetation to gas field elements has a measurable effect on pygmy rabbit distribution and abundance.

THE EFFECTS OF OIL AND GAS DEVELOPMENT FOR AQUATIC HABITATS

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The rapid expansion of oil and natural gas development in southwest Wyoming has raised concerns about the effects for key wildlife species and habitats. Aquatic habitats are essential for Wyoming's fish and wildlife communities. Oil and gas drilling practices and associated infrastructure can alter aquatic habitats through increased road densities and vehicle traffic, fragmentation of habitat, water use, and pollution of air, water, and soil. We examined habitat and water quality across stream sites in southwest Wyoming that are overlaid by the LaBarge Oil and Gas Field. We found that stream reaches that were highly affected by oil and natural gas development had degraded habitat conditions, as indicated by reduced riparian cover, increased fine suspended sediment, and reduced water quality. These shifts in habitat quality are reflected in the fish community. Improved understanding of the effects of oil and gas development on aquatic habitats will allow more explicit management and mitigation recommendations for the protection of these habitats and the communities that depend on them.

DOES OIL AND NATURAL GAS DEVELOPMENT AND HYDROLOGY INTERACT TO AFFECT FISH POPULATION DYNAMICS?

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Managers and ecologists are under increased pressure to quantify and understand how stressors, natural or anthropogenic, interact to affect environmental and ecological change. Oil and natural gas development has expanded at an unprecedented rate and our understanding of how stressors associated with these activities affect aquatic ecosystems is limited. Hydrology is also an important driver of chemical, physical, and biological processes in stream ecosystems. Oil and natural gas development and altered hydrology have been shown to individually affect stream biota; however less is known regarding how these stressors interact to affect ecological change. The objective of this study is to examine the potential interaction between oil and natural gas development and natural annual variation in hydrology on fish population dynamics. Specifically, we examined changes in the abundance of mottled sculpin (*Cottus bairdii*), mountain sucker (*Catostomus*

platyrhynchus), and Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) at 60 sites in the Wyoming Range between 2012 and 2015. Overall, very few mottled sculpin and no cutthroat trout were collected from high development sites, though mountain suckers were present in good abundances. At sites with lower levels of development, all species exhibited similar oscillating patterns in abundance that could potentially be linked with the previous year's stream discharge. Preliminary results suggest that mountain sucker abundance may shift through time in relation to interactions of development and hydrology. By understanding the interactions between anthropogenic and natural stressors, we can better inform managers and conservation biologists of best management practices that may be needed to reduce negative effects for chemical, physical, and biological processes in stream ecosystems.

INVESTIGATION OF MERCURY INPUTS AND BIOGEOCHEMICAL CYCLING IN BIGHORN LAKE, BIGHORN CANYON NATIONAL RECREATION AREA, MONTANA, AND WYOMING

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Mercury (Hg) bioaccumulation is a major risk to aquatic ecosystems of national parks and recreation areas in the western United States. Elevated Hg concentrations in walleye and catfish tissue samples obtained from in Bighorn Lake within the Bighorn Canyon National Recreation (BICA) resulted in fish consumption advisories in Wyoming and Montana. Management of this issue is complex because there are several potential point sources of Hg near BICA (geothermal and anthropogenic), as well as atmospheric sources. An additional concern is the input of selenium (Se) to Bighorn Lake and the associated antagonistic interaction of Se and Hg with respect to toxicity modifications in fish. High sedimentation rates in the upper part of Bighorn Lake will require remediation in the near future. Additional information on Hg cycling in the reservoir is needed to assess the potential effects of sediment remediation on Hg bioaccumulation in fish. An increased understanding of Se and Hg sources entering BICA from the major tributaries (Shoshone River and Bighorn River) and the biogeochemical cycling and transfer of Hg through the food web to top predators could identify sediment management strategies that also reduce metal concentrations in BICA fish. We have begun to characterize the sources and concentrations of Hg and Se entering BICA by collecting water and sediment samples from 7 sites during a synoptic sampling event. Near-surface sediment samples were analyzed for Se total, Hg total, MeHg, and ratios of selected Hg isotopes. Whole-water and filtered water samples from different depths were analyzed for Se, Hg, and MeHg. Water column and sediment samples were collected for microbial analysis at the 7 sites using sterile techniques. Geochemical and microbial results from this study will increase the understanding of Se and Hg sources and cycling in BICA.

Session 4. Adapting Management, Revising Policy

Spatial and temporal interactions between species (including humans) are important components of mitigation, management, and study. In this session, we explore how wildlife interact with their surroundings including: infrastructure and disturbance, wildlife dispersal, dietary overlap, population structure and dynamics, habitat and water issues, and the elements of management that play roles in understanding these topics. This session is presented with an underlying emphasis on well-informed future management, mitigation strategies, and policies.

META-ANALYSIS OF WILD HORSE DIET COMPOSITION AND CONFLICT WITH LIVESTOCK AND WILD UNGULATES ON WESTERN RANGELANDS OF NORTH AMERICA

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Wild horse (*Equus ferus caballus*) management on western North American is an escalating concern for ecological integrity on these landscapes. Identifying potential diet overlap between horses, livestock, and wildlife will inform management decisions to optimize multiple interests. To understand dietary relationships, we conducted a quantitative synthesis of microhistological fecal studies for wild horse, beef cattle (*Bos* spp.), domestic sheep (*Ovis aries*), elk (*Cervus elaphus*), pronghorn (*Antilocapra americana*), and mule deer (*Odocoileus hemionus*) diet composition on western rangelands of North America. Our search yielded 60 studies from 14 states, 1 Canadian province, and 2 Mexican states with 392 unique species-season samples. We summarized plant species into graminoid, forb, and browse functional groups. For wild horses, seasonal diet composition means for graminoids (77 to 89%), forbs (4 to 15%), and browse (3 to 10%) did not vary seasonally for any plant group ($P \leq 0.05$). Univariate analyses and the calculation of effect sizes corroborated our finding that graminoid composition explained the potential overlap of wild horses with cattle regardless of season, with sheep and elk in the spring, with sheep in the summer, and with elk in the fall and winter. Although data indicate wild horse diets are primarily composed of graminoids, several studies reported unusual regionally specific shifts in response to winter snow that limited graminoid accessibility, leading to higher browse composition. Season, plant composition, and herbivore assemblage may all influence dietary competition between wild horses and other large herbivores sharing western North American rangelands; however, the low and non-significant heterogeneity values at alpha 0.01 for cattle:horse effect size comparisons suggest that cattle and horses respond to regional and seasonal variation similarly—a result not observed for other herbivore:horse comparisons. Our meta-analysis provides a robust data set for evaluations of diet composition for wild horses, livestock and wildlife, whereas no empirical studies have assessed all species together.

WATER SHORTAGE, CLIMATE CHANGE, AND AGENCY LAND MANAGEMENT

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Between 1966 and 2006 the total surface area of 44 Wind River Mountain glaciers decreased 38%. Glaciers and other frozen "assets" have supplied 75% of water for the western United States. Nonetheless, annual April snowpack measurements taken between 1956 and 2014 document decreasing water yield from about 80% of western mountains. Frozen-storage losses could be

mitigated by liquid storage in wetlands, marshes, beaver ponds, peat beds, and other riparian features. However these wetlands, in order to retain or increase water yield, must be in proper functioning condition. A majority of BLM-managed wetlands in the lower 48 states are *not* in proper functioning condition. We review data collected from public-land riparian systems to illustrate what has been lost. We also review successes in restoring riparian function. These successes have required 20 or more years to implement for a variety of reasons. Land management agency action to regain or protect proper functioning riparian systems has been and will continue to be successful. Under expected climate-change scenarios, worsening West- wide water shortages are likely to continue unless the liquid-water storage capacity of the region can be restored.

THE ELEMENTS OF SUCCESS IN FISH AND WILDLIFE MANAGEMENT: LOOKING BACK AT THE SUCCESSES AND FAILURES OF WILDLIFE CONSERVATION TO GUIDE THE PROFESSION OVER THE NEXT 100 YEARS

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In 2015, the 100th year of the North American Wildlife and Natural Resources Conference, the Wildlife Management Institute (WMI) and the Steering Committee for the Conference chose a unique approach for the plenary keynote address. Rather than have an outside keynote speaker, or even a conference official, the committee took Paul Hansen's suggestion to hear from the profession itself. For this project, fish and wildlife professionals were surveyed for their opinions and ideas concerning successes and failures over the past 100 years of fish and wildlife management, including the strategies that were responsible for those successes, the strategies that did not work, and the implications of those successful and unsuccessful strategies for the future of fish and wildlife management in the next 100 years in North America. To achieve this task as scientifically as possible, WMI, Paul Hansen and Rollin Sparrowe and the Steering Committee partnered with Responsive Management to conduct the survey of fish and wildlife professionals. The results provided substantial insight into the strengths and weaknesses within the fish and wildlife management profession. While some of the findings may have been expected, other results were illuminating and thought-provoking. Overall, the fish and wildlife management efforts that are considered by the professionals who implement them to be the most successful over the past 100 years are: dedicated funds (such as the Federal Aid in Wildlife and Sport Fish Restoration funds and the Duck Stamp), species recovery and management, the Endangered Species Act (ESA), land conservation, and the North American Model of Wildlife Conservation. However, these initiatives and the Model itself have aspects that are problematic in their implementation that were highlighted by professionals.

IS THERE A CASE FOR AGE IN UNGULATES?

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Long-lived herbivores possess a conservative life-history strategy, wherein individuals seek to conserve their own survival at the cost of current reproduction. Age is a key life-history characteristic that has important effects on the behavior and performance of individuals, from

influencing behavioral decisions, reproduction and reproductive effort, survival and mortality rate, and fat accretion and catabolism, among other key components. With little doubt, data on age of individual animals or age structure of populations is important for both research and management. To incorporate age as a covariate, some researchers have employed techniques to age individuals based on toothwear and replacement, which in general is more subjective and less accurate than cementum annuli but can be done without tooth extraction. To provide a more accurate estimate, in the late 90s, researchers began extracting a canine or incisiform canine from study animals. The consideration of whether to extract a tooth from ungulates for research and monitoring was debated in the literature over a decade ago. Since that time, methods have been modified, strategies to mitigate pain have been refined, and products to aid in achieving hemostasis have been developed. The primary consideration at this point is whether a tooth should be extracted, because the methods have been effectively worked out, and no resulting consequences of the extraction observed. What remains is an ethical question: "is the cost of tooth extraction to the individual worth the gain in knowledge for the study, population, or species in question?" Through a literature review and post-hoc analyses of available data from longitudinal captures of mule deer (*Odocoileus hemionus*), I evaluate the current evidence as to the effects of tooth extraction and discuss the ethical aspects associated with tooth extraction in ungulates.

DEER-VEHICLE COLLISIONS IN WYOMING: CHALLENGES AND OPPORTUNITIES

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Collisions between vehicles and large mammals pose a threat to human safety and to wildlife populations. In Wyoming, the majority of collisions involve deer, averaging about 5,000 deer mortalities and costing $44-52 million per year. Crossing structures (road under- or over-passes, coupled with fencing) are the most effective means of mitigating this problem. In an analysis of the patterns of wildlife-vehicle collisions across Wyoming, we found that collisions were strongly associated with agricultural land outside of major towns – areas where it may not be feasible to install fencing and crossing structures. In places such as this, there is a need for effective mitigations that allow animals to safely cross roads without completely isolating them from the roadway. Roadside "wildlife reflectors" are marketed to accomplish this – by reflecting the beams of oncoming vehicles and "warning" animals not to cross. However, the evidence supporting the effectiveness of these reflectors is equivocal. We conducted a study of the efficacy of Streiter-Lite reflectors in central WY. In our first experiment, reflectors were either exposed or covered with white canvas bags. In a follow-up experiment, reflectors were either exposed or covered with black canvas bags. We found that carcass densities were 32% lower when reflectors were exposed compared to black bags, but 33% lower when covered with white bags than when they were exposed. Using direct observations of deer road-crossing behavior, we also found that deer were most likely to engage in safer, more vigilant road crossing behavior in the white bags treatment. These surprising results suggest that the white canvas bags are not only more effective than the reflectors, but were more effective than any other currently-existing mitigation that does not require fencing the roadway. These results suggest a possible new method for reducing the problem of wildlife-vehicle collisions in Wyoming and around the world.

FUNCTIONALITY OF LARGE CARNIVORE RANGE EXPANSION; EMPLOYING FIELD DATA AND MODELING EFFORTS TO EVALUATE MOUNTAIN LION RECOLONIZATION

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Over the last decade, a resurgence of large carnivore/omnivore populations has occurred, with range expansion being documented for mountain lions (*Puma concolor*), grizzly bears (*Ursus arctos*), black bears (*U. americanus*), and wolves (*Canis lupus*) in multiple locales across the continent. Dispersal plays a vital role in population ecology and is a driving factor of realized range expansion of wildlife populations. The naturally recolonized mountain lion population in the Black Hills of South Dakota and Wyoming offers a long term dataset to evaluate the role of dispersal in relation to true range expansion and recolonization of an apex predator in North America. Our primary objective was to document dispersal movements in relation to range expansion of mountain lions captured within the Black Hills ecosystem of southwestern South Dakota and eastern Wyoming, with an updated focus on female dispersal within and beyond the ecosystem. We documented several (n = 8) long-distance dispersal movements (>250 km) of male mountain lions and hypothesize that males making long-distance movements were in search of available mates. Since initial publication of results, we have documented several (n = 3) long-distance female dispersal movements. In order to address the notions of recolonization into eastern North America, we quantified potential mountain lion habitat in the Midwest, and modeled two scenarios that could impact recolonization of mountain lions (annual harvest of cougars in western populations vs. no harvest) in a spatially-explicit population viability analysis (PVA). Under both scenarios, results suggested that female mountain lions are likely to recolonize large patches of habitat in the Midwest within the next 25 years. The dispersal movements documented by our study indicate that range expansion and habitat recolonization are occurring and further suggest proactive efforts to increase public knowledge of mountain lion ecology in areas where they are recolonizing previously occupied range.

POWER POLE DENSITY INFORMS SPATIAL PRIORITIZATION FOR MITIGATING AVIAN ELECTROCUTION

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Raptor and corvid electrocutions are a continental conservation concern. Despite the scope of the problem, mitigation is typically implemented at the local scales of individual electric utilities. By not considering landscape-scale patterns, conservation strategies may fail to focus mitigation where efforts are needed most. To enable resource managers to consider electrocution risk at larger scales, we developed a regional model of distribution power pole (pole) density in a grid of 1 square kilometer (km^2) cells throughout Wyoming and Colorado. To do so, we obtained data on pole locations from a sample of electric utilities covering 31% of Colorado and Wyoming to develop a predictive model using a Random Forest machine learning classification procedure based on

anthropogenic and natural land-cover characteristics. We used out-of-sample validation to test the model and then predicted pole density across Wyoming and Colorado. Pole density was influenced by road lengths, number of oil and gas wells, slope, development, and land cover. Poles were densest in areas with high road lengths, high numbers of wells, and relatively flat terrain, and in areas developed for agriculture or human residences. When model predictions are viewed together with species-specific habitat maps, locations where high pole densities overlap high-quality habitat suggest areas where mitigating electrocution risk could be prioritized. Communication between resource managers and local utilities could then clarify whether poles in areas of concern were at-risk. As an example, we compared model predictions with Golden Eagle (*Aquila chrysaetos*) nesting habitat in northeastern Wyoming to identify candidate areas of high electrocution potential. If poles in these areas were not built or previously retrofitted to minimize electrocution risk, retrofitting measures focused there may offer substantial conservation impacts. Thus, the model provides a framework for systematic spatial prioritization in support of regional conservation planning.

EFFECTS OF CHRONIC WASTING DISEASE ON FREE-RANGING DEER POPULATIONS IN WYOMING

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Few studies have investigated the persistence of wildlife populations in response to disease. Furthermore, wildlife disease research often underscores pathogens that cause mass mortalities rather than chronic diseases that cause high morbidity and mortality over longer timespans. Chronic wasting disease (CWD), an invariably fatal transmissible spongiform encephalopathy of deer (*Odocoileus* spp.), elk (*Cervus elaphus nelsoni*), and moose (*Alces alces shirasi*) provides a framework to study the long-term effects of an endemic disease with incubation periods >12 months on free-ranging cervid populations. We hypothesized that CWD greatly reduces survival and reproduction causing annual population declines. Specifically, we determined the effect of CWD on mule deer (*O. hemionus*) demography using a Leslie matrix model to calculate the finite rate of population growth (λ). We captured adult ($\geq$ 1.5 years old) deer from 2010 – 2014 in southeastern Wyoming where CWD prevalence typically exceeded 20% annually. Deer were ante-mortem CWD tested using tonsil biopsies and monitored using radio-telemetry and global positioning system collars. We found that CWD decreased adult annual survival; however, fawn production was not significantly influenced by infection. We estimated $\lambda = 0.81$ suggesting an annual population decline of 19% under current conditions. However, when CWD was excluded from the model $\lambda = 1$ suggesting stable annual population growth rates in the absence of CWD. A study of sympatric white-tailed deer (*O. virginianus*) found similar results with an annual population reduction of 10%, but an increasing population growth rate ($\lambda = 1.07$) when CWD was omitted from their model. These findings suggest endemic CWD is a population-limiting disease of deer and chronic diseases with protracted incubation periods can cause significant population declines.

EVALUATING EFFECTS OF HABITAT CONDITION, WEATHER AND PREDATOR DENSITY ON SHIRAS MOOSE DEMOGRAPHY

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Over the past two decades, populations of Shiras moose (*Alces alces shirasi*) in western Wyoming have declined. Recent work on the Jackson herd in northwest Wyoming suggests that the 1988 Yellowstone fires and regional drought contributed to a considerable decline in calf recruitment, which coincided with the recovery of grizzly bears (*Ursus arctos horribilis*) and gray wolves (*Canis lupus occidentalis*) to the Greater Yellowstone Ecosystem (GYE). Predation is also presumed to have contributed to declines in calf recruitment, but the relative influence of these predators has yet to be evaluated. We analyzed a time series of vital rates to identify the spatial extent and intensity at which predator density, habitat condition, and interacting abiotic factors limit population growth. We focused on neonate survival because calves are most vulnerable at this time and because calf recruitment has been shown to be one of the most important vital rates influencing population dynamics in large herbivores. Variables affecting neonate survival were calculated at the home range scale from 100 individuals in the Jackson herd, and 90 individuals in an adjacent herd directly to the south, where moose are exposed to markedly lower predator density. The most influential variables for neonate survival were winter severity from the previous year, burn severity of summer home ranges, and grizzly bear density. Our spatial analysis of individual fitness in these two herds suggests that Shiras moose in the GYE have struggled to cope simultaneously with significant effects of sub-optimal habitat conditions, adverse weather, and predator density, highlighting the need to prioritize efforts to conserve Shiras moose.

Session 5. Conservation and Research of Threatened Species and Species of Concern

In order to make informed decisions on the conservation and management of threatened or endangered species it is vital that biologist adhere to the tenets of the scientific method and that research and monitoring efforts produce results with applicability in the realm of on the ground conservation and management efforts. This session will explore research and applicable conservation efforts for species of concern throughout the state, spanning multiple classes and genera of Wyoming wildlife.

OCCUPANCY OF NORTHERN LONG-EARED BAT (*MYOTIS SEPTENTRIONALIS*) IN WYOMING

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Bats are an important component of ecosystems worldwide. Unfortunately, many bat species have undergone large population declines and are faced with increasing risk of extinction. Northern Long-eared Bat (NLEB) was petitioned for listing under the Endangered Species Act in 2010. The primary factor threating the species cited in the petition was the large impact of White-Nose Syndrome (WNS) to the species throughout a large portion of its range in eastern North America. In April 2015, USFWS determined the species warranted threatened species status. In Wyoming, the species is limited to the Black Hills and Bear Lodge Mountains of northeastern Wyoming. Basic knowledge of habitat use and associations of NLEB in Wyoming is limited. In 2014, we placed paired acoustic recording devices at spatially balanced random sample locations across the species range in Wyoming. At these sites, we collected extensive habitat data to characterize forest structure. Using these data, we estimated detection probability and occupancy probability of NLEB using a two-step modeling approach. First, we identified the best model for estimating detection probability. Then, using the best detection function and habitat covariates, we identified the best model for estimating occupancy probability. The best detection function for NLEB did not include any covariates, indicating that detection did not vary with the covariates included in our detection models. The estimated detection probability for NLEB was low (p = 0.273; SE = 0.094). The highest ranked occupancy model estimated that NLEB was present at approximately half of potential survey locations (ψ = 0.489; SE = 0.202). This model contained covariates for the density and DBH of live trees and suggests that the probability of occupancy increased with the density and DBH of live trees. This model aligns with our expectations because NLEB is a forest obligate species frequently found in relatively dense forests.

A REVIEW OF SPATIAL AND TEMPORAL PATTERNS IN GOLDEN EAGLE DIETS IN THE WESTERN UNITED STATES, WITH IMPLICATIONS FOR CONSERVATION PLANNING

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Food habits of Golden Eagles (*Aquila chrysaetos*) are of increasing interest to wildlife managers seeking to mitigate the impacts of energy development across the western United States. We compiled a geodatabase of published and unpublished Golden Eagle prey data in order to characterize spatial and temporal patterns in prey use, investigate ecological relationships between

Golden Eagles and prey communities, and inform conservation planning. We analyzed 30 studies identifying 42,841 individual prey during the breeding season from 1954-2015 and found principal prey groups differed among western ecosystems. Dietary breadth varied from 1.36 to 12.27, with lower breadth associated with desert and shrub-steppe ecosystems and higher with mountain ranges and the Columbia Plateau. Diets in the Wyoming Basin were characterized by high frequencies of leporids while predation on sciurids varied (0–45%) among studies. Analysis of long-term data from southwest Idaho indicated prey switching from leporid to sciurid species in response to habitat change caused by wildfire and cheatgrass (*Bromus tectorum*) invasion. Similarly, Golden Eagles in Central Utah fed more frequently on rock squirrel (*Otospermophilus variegatus*) in years with decreased use of jackrabbits (*Lepus* spp.) and cottontails (*Sylvilagus* spp.). These results support the conclusion that Golden Eagles are opportunistic generalist predators that specialize on locally available prey species. Spatial and temporal variations in Golden Eagle diet likely reflect changes in prey community structure in response to environmental factors, such as drought and invasive species, that affect prey species abundance, distribution, and availability. A diverse prey base could be important for allowing Golden Eagles to shift among alternative prey in response to changing conditions. Land management practices that support or restore shrub-steppe ecosystem diversity should therefore benefit Golden Eagles. More information is needed on diet during the nonbreeding season to determine what food resources, such as carrion, are important for over-winter survival.

ROCKY MOUNTAIN AMPHIBIAN PROJECT: BIOLOGISTS AND CITIZEN SCIENTISTS WORKING TOGETHER TO MONITOR AMPHIBIANS

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Monitoring amphibians is necessary but difficult and rarely attempted at large spatial scales. The Rocky Mountain Amphibian Project (RMAP) monitors amphibians by coordinating annual standardized surveys in predefined areas (catchments) on Forest Service lands in southern and western Wyoming and northern Colorado. The monitoring initiative began in 2012 and has expanded to include over 350 wetland sites in 70 catchments. In order to make the project sustainable, we began involving citizen scientists in 2014 to augment surveys conducted by biologists and technicians. Partners now include the Wyoming Natural Diversity Database, Wyoming Game and Fish Department, UW Biodiversity Institute, Medicine Bow-Routt National Forests, Bridger-Teton National Forest, Wyoming Geographic Information Science Center, The Nature Conservancy, Trout Unlimited, USGS Amphibian Research and Monitoring Initiative (ARMI), and Boy Scouts of America. The RMAP study design incorporates USGS ARMI guidelines for their mid-level occupancy-based modeling approach and methods closely resemble those used in Yellowstone and Grand Teton National Parks. Surveys follow standardized protocols designed to accommodate estimation of species detection probabilities. Biologists and citizen scientists either attend trainings or watch training videos before conducting surveys. Volunteer commitment and data quality has been excellent. In 2014, 78 volunteers conducted 174 surveys at 95 wetland sites across 18 catchments and hiked over 273 miles of mountainous terrain. We present preliminary results from 4 years of amphibian monitoring. We also compare the probability of detecting species and the quality and completeness of survey data collected by volunteers and by biologists and technicians. Assistance from trained citizen scientists will allow resource managers to collect data annually from a sufficient number of areas to track amphibian occupancy across large landscapes.

BREEDING SUCCESS AND NON-BREEDING SEASON HABITAT USE PATTERNS OF LONG-BILLED CURLEWS IN WESTERN WYOMING

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The Long-billed Curlew (*Numenius americanus*), a shorebird that nests in grassland habitats, is a designated Species of Greatest Conservation Need in Wyoming, a U.S. Fish and Wildlife (USFWS) Species of Conservation Concern, and a BLM sensitive species. Wyoming Game and Fish Department funded a study in the early 1980's to survey breeding distributions in western Wyoming and identified an area near Daniel as having the highest breeding density in the state. Roadside surveys since the 1990s suggest that numbers may have declined in WY. Similarly, declines have been recently documented in some areas of Idaho. To investigate the current status of this species, preliminary work began in 2014, when Intermountain Bird Observatory (IBO) tagged the first Wyoming curlew with a satellite transmitter on the National Elk Refuge in Jackson. This female adult ended up wintering at a site on the coast of western Mexico where no previously marked curlews from the Intermountain West had been documented. In 2015, IBO studied reproductive success at six breeding sites in Wyoming, Idaho and Montana including the two historic study areas in Pinedale and Daniel and a new site in Cody. Seven additional curlews were tagged in Wyoming and migration data from fall 2015 suggest that there may be a divide in Wyoming's birds. Curlews from the Jackson and Pinedale areas migrated to sites in the Imperial Valley and western Mexico compared to the Cody birds which moved to central Mexico. This talk will present preliminary demographic data from Wyoming and discuss conservation risks and opportunities for this species. Support for this study was generously provided by Wyoming state legislative funds, the Bureau of Land Management, Wyoming Governor's Big Game License Coalition, and the Meg and Bert Raynes Wildlife Fund.

GOLDEN EAGLE DIET AND PRODUCTIVITY IN RELATION TO FLUCTUATIONS IN PRIMARY PREY ABUNDANCE IN WYOMING'S BIGHORN BASIN

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Between 2009 and 2015, Golden Eagle nesting success (number of nests producing at least one chick to fledging age/number of occupied nesting areas) ranged between 32% and 77%, and productivity ranged between 0.33 fledglings/occupied nesting area and 1.25 fledglings/occupied nesting area. Cottontails (*Sylvilagus* spp.) were the most frequently occurring prey in the Golden Eagle nesting diet (determined by prey remains in nest) in each year of our study, ranging from 48% of individuals identified to 86% of individuals identified. Hunter surveys indicate that cottontails in Wyoming exhibit dramatic, cyclic population fluctuations, peaking approximately every six to eight years. Data we acquired through roadside spotlight surveys in the Bighorn Basin are generally consistent with the statewide hunter survey data. The number of cottontails we detected during our peak year (2015) was nearly triple the number of cottontails we detected in our trough year (2013). Golden Eagle nesting diet breadth increased when cottontail abundance declined, but no other single prey species gained singular importance. Golden Eagle nesting success and productivity plummeted when cottontail abundance dropped, despite nesting eagles exploiting a wider range of prey during years when cottontail abundance was low. The multiple-use, sagebrush-

steppe environment in the Bighorn Basin is undergoing profound changes related to exurban sprawl, energy development, and recreational activities. Thus, a key to Golden Eagle conservation, at least in the changing world of the Bighorn Basin, lies in maintaining or enhancing environmental conditions that support robust, albeit cyclic, cottontail populations.

WYOMING'S SPINELESS WILDLIFE: CURRENT STATUS OF RARE INVERTEBRATES IN WYOMING

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Wyoming's wildlife is composed of vastly more invertebrates than vertebrates; in fact, about 99% of animal taxa in the state and on the planet lack spines. Invertebrate animals increase plant fecundity via pollination, regulate plant biomass through herbivory, make up a large fraction of the diet of many vertebrate animals, contribute to decomposition and nutrient cycling, and affect many other fundamental ecological processes. Despite their high diversity, ubiquity and various contributions to ecosystems, far less is known about invertebrate compared to vertebrate animals. The frequent lack of basic information makes identifying and managing rare and sensitive invertebrates extremely difficult. The Wyoming Natural Diversity Database at the University of Wyoming summarized existing knowledge of rare invertebrates in the state. Currently, 131 invertebrate taxa of concern (32 insects, 28 crustaceans, 71 mollusks) are known to occupy the state. No invertebrates are currently protected under the Endangered Species Act in Wyoming; however, four insects and 11 mollusks are ESA-listed in neighboring states. ESA petitions for invertebrates appear to be increasing in frequency across the region and three Wyoming invertebrates (Narrow-footed Predaceous Diving Beetle, Monarch Butterfly, Regal Fritillary) are currently petitioned for ESA listing. This presentation will introduce Wyoming invertebrates of concern and discuss how ESA-listed invertebrates may impact the state.

DENSITY DEPENDENCE, WHITEBARK PINE, AND VITAL RATES OF YELLOWSTONE GRIZZLY BEARS

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Understanding factors influencing changes in population trajectory is important for effective wildlife management, particularly for populations of conservation concern. Annual population growth of the grizzly bear (Ursus arctos) population in the Greater Yellowstone Ecosystem, USA has slowed from 4.2–7.6% during 1983–2001 to 0.3–2.2% during 2002–2011. Substantial changes in availability of a key food source and bear population density have occurred. Whitebark pine (Pinus albicaulis), the seeds of which are a valuable but variable fall food for grizzly bears, has experienced substantial mortality primarily due to a mountain pine beetle (Dendroctonus ponderosae) outbreak that started in the early 2000s. Positive growth rates of grizzly bears have resulted in populations reaching high densities in some areas and have contributed to continued range expansion. We tested research hypotheses to examine if changes in vital rates detected during

the past decade were more associated with whitebark pine decline or, alternatively, increasing grizzly bear density. We focused our assessment on known-fate data to estimate survival of cubs-of-the-year (cubs), yearlings, and independent bears (≥2 yrs), and reproductive transition of females from having no offspring to having cubs. We used spatially and temporally explicit indices for grizzly bear density and whitebark pine mortality as individual covariates. Models indicated moderate support for an increase in survival of independent male bears over 1983–2012, whereas independent female survival did not change. Cub survival, yearling survival, and reproductive transition from no offspring to cubs all changed during the 30-year study period, with lower rates evident during the last 10–15 years. Cub survival and reproductive transition were negatively associated with an index of grizzly bear density, indicating greater declines where bear densities were higher. Our analyses did not support a similar relationship for the index of whitebark pine mortality. The results of our study support the interpretation that slowing of population growth during the last decade was associated more with increasing grizzly bear density than the decline in whitebark pine. Grizzly bear density and its potential effect on vital rates and population trajectory warrant consideration for management of the grizzly bear population in the Greater Yellowstone Ecosystem.

DO SAGE-GROUSE CORE AREAS PROTECT NON-GAME WILDLIFE OF CONCERN?

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Wyoming is among nearly a dozen western states/provinces that have delineated core population areas for the Greater Sage-Grouse (*Centrocercus urophasianus*). These semi-protected areas contributed to the recent decision that sage-grouse do not warrant protection under the U.S. Endangered Species Act, and will likely be maintained in the continued effort to stave of sage-grouse population declines. Many suppose that such protections for sage-grouse also support hundreds of other species associated with sagebrush-steppe habitats; however, few studies have documented the extent to which this is a valid assumption. We addressed three questions: 1) How much overlap does the Core Area have with the suitable habitat of 52 of Wyoming's Species of Greatest Conservation Need (SGCN)? 2) If the Core Area was bigger or smaller, how would that affect those SGCN species? 3) Does the Core Area protect SGCN species' habitat just because the Core Area is really big? 4) Which kinds of SGCN are best protected by the Core Area? We found that the proportion of each species' habitat that overlaps the Core Area ranges from 0-63% (median = 17%). Second, the bigger the Core Area, the better it is for more SGCN species. Hypothetical Core Areas sited with no respect to sage-grouse populations, moreover, but equal in size to the established Core Area, protected as much, or more SGCN habitat than the established Core Area did, for 40 of the 52 SGCN species. Finally, SGCN species most similar to sage-grouse are the best served by the sage-grouse Core Area. Our findings confirm that many at-risk species receive some protection under the umbrella of sage-grouse conservation, but with important caveats about Core Area size and species attributes, and species that do not appear to fit under the sage-grouse umbrella.

Session 6. Dynamics of sage-grouse populations and sagebrush habitats

Successful management and conservation of sage-grouse and sagebrush habitats requires understanding of dynamics of populations, changes in habitat conditions, and integration of the influences of people on populations and habitats with other natural patterns. In this session, we present a series of talks aimed at better understanding populations, habitat conditions or both. These presentations each focus on a different aspect of these relationships (harvest management, population modeling, habitat management and manipulation, land-use and climate trends) providing a demonstration of a wide-range of methods, and illustrating the many facets to be considered when managing widely distributed species and habitats.

PREDICTION OF ANNUAL ESTIMATED HARVEST OF GREATER SAGE-GROUSE BASED ON SEASON REGULATIONS, SURVEY BIAS, AND HUNTER ACCESS

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During the past 100 years, regulated harvest of greater sage-grouse (*Centrocercus urophasianus*; hereafter ”sage-grouse”) has been overseen by 11 state and two provincial wildlife management agencies throughout western North America. These agencies progressively changed harvest season regulations to reduce the potential for negative effects of hunter harvest on sage-grouse populations. Changes to season regulations (area open, bag/possession limits, season length, and season start date) are the primary mechanism that wildlife agencies use to manipulate the number of upland game harvested annually. However, there has not been a robust assessment of the relationship of each season regulation in manipulating numbers harvested. The true number of sage-grouse harvested annually is unknown, but management agencies conduct harvest surveys to estimate the number harvested each year. Concurrently, there has been recognition that survey bias existed historically, and factors outside of the control of management agencies lead to differential exposure to harvest (i.e., cities, human population density, land ownership, roads, and weather during the hunting season). We used generalized linear mixed models to evaluate the influence of harvest season regulations, harvest survey variables (hunt type [sage-grouse versus upland game] and survey type [mail, permit, phone, or web]), and exposure to harvest variables on the annual estimated number of sage-grouse harvested. Our analysis spanned 1995 to 2013 and included harvest data from California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, and Wyoming. Estimated harvest numbers were positively associated with possession limit, earlier and wetter opening weekends, and closer proximity to a city. Mail-in harvest surveys and upland game hunts produced higher harvest estimates compared to permit, phone, and web surveys and sage-grouse specific hunts, respectively. Harvest regulations implemented by management agencies were effective at reducing the number of harvested sage-grouse; however, care needs to be taken when comparing harvest estimates with different harvest survey methodologies.

MULTI-SCALE STATEWIDE WYOMING GREATER SAGE-GROUSE POPULATION VIABILITY ANALYSIS

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Greater Sage-grouse (sage-grouse; *Centrocercus urophasianus*) populations occupy 56% of historic range in North America. However, Wyoming remains a stronghold for sage-grouse, representing approximately 37% of species' distribution. Research indicates widespread population-level declines have occurred due to habitat loss and fragmentation. Unprecedented conservation efforts were required to prevent listing of sage-grouse under the Endangered Species Act (September 2015), but sage-grouse remain a species of concern. We investigated trends for Wyoming sage-grouse populations. We developed lek clusters using a minimum spanning tree algorithm informed from sage-grouse habitat surrogates. We then used population viability analysis (PVA) and tested density-independent (DI) and density-dependent (DD) models within each cluster to account for movements between leks. Lek count data (Wyoming Game and Fish Department) were used in models after averaging number of peak male counts per lek annually. Counts were limited to those collected from 1993 to 2015, during March 1–May 31, and 30 minutes pre-sunrise to 90 minutes post-sunrise. The DI model resulted in lambda values (λ, finite rate of population growth) of 1.01 statewide and <1.0 for two out of ten clusters for the period 1993-2015 (range: 0.96 – 1.26), and 0.98 statewide and <1.0 for seven out of ten clusters for the period 1993-2014 (range: 0.94 – 1.29). The DD models resulted in λ<1.0 for the statewide population and all ten clusters for both time periods. Results indicate population increase in 2015 had large impact on raising λ for DI model but not for DD models. Further monitoring is required to determine if populations will continue to increase. Currently we are further generating another spatially hierarchical cluster level to continue PVA at a finer scale. Clusters will allow managers to target populations that are in greatest need of conservation attention, based on our PVA and current and future threats on the landscape.

A BAYESIAN STATE-SPACE MODEL TO ESTIMATE SAGE-GROUSE TRENDS: IMPACTS OF OIL AND GAS DEVELOPMENT

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Sagebrush ecosystems in the United States have experienced significant changes over the last century resulting in an approximately 50% loss, due to grazing, fire, and agricultural, urban, and energy development. The greater sage-grouse (*Centrocercus urophasianus*) is dependent on sagebrush throughout its life history and, therefore, has also experienced large declines in distribution and abundance. One potential threat to populations is the increase in development associated with oil and natural gas extraction. Wyoming contains approximately 40% of sage-grouse range-wide and has experienced a rapid increase in energy development, with that trend expected to continue with increased energy demands. Understanding how these changes may impact populations could help guide future management of populations. We used a Bayesian state-space model to estimate the impacts of energy development, habitat, and precipitation on changes in lek attendance of male sage-grouse in Wyoming from 1984-2008. We explored these covariates at various scales and time lags to account for demographic and behavioral responses to development. We found annual declines in lek attendance of 1.3% across the state, with regional trends ranging from -9.5% to 2.6%. Well density within 6.4 km of a lek at a 4-year lag provided the best predictive ability of all energy development metrics and had negative impacts on lek attendance. Sagebrush cover had no effect and average spring precipitation within 3.2 km two years prior had a negative effect on changes in lek attendance. Our findings suggest that sage-grouse may experience further declines in Wyoming as energy development is expected to increase in the future. A combination of restrictions on development, mitigating efforts, and restoration of sagebrush may offset the impacts of oil and gas development on sage-grouse populations.

MITIGATION BY DESIGN IN WYOMING: MAKING THE CONNECTION BETWEEN WILDLIFE DISTRIBUTION, HABITAT, RESTORATION, AND MITIGATION

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Many areas within designated priority habitats, including Core Areas are currently below average condition such that habitat distributions at local and regional scales may be improved to affect the long-term persistence of sage-grouse, and other wildlife. Securing and/or improving the condition of sagebrush habitats within currently important habitat areas is likely to provide durable conservation benefit, including population responses, if well targeted and designed. Land managers and land-use planners have described the need for help in identifying valuable habitat areas that also have high potential for cost-effective restoration for planning and implementation across large landscapes. Using a combination of habitat delineations and maps with environmental conditions that affect habitat conditions and dynamics, including restoration potential, we have developed models of locations and environmental conditions with strong potential for successful restoration of both vegetation conditions and habitat utilization. Multivariate models are used to project the distribution of potential habitats based on correlations between variables representing environmental conditions (e.g., soil, climate), the distribution of shrubs (esp. sagebrush) and the distribution of species and/or habitat (e.g., sage-grouse leks), brood-rearing habitats, and winter habitats. The decision framework combines seasonal habitat models and associated predictors (especially sagebrush cover), environmental conditions including soil and climate, and records from previous restoration efforts to describe and project locations with best potential for restoration.

GREATER SAGE-GROUSE RESPONSE TO GRAZING TIMING AND INTENSITY IN WYOMING

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Population declines of Greater sage-grouse (*Centrocercus urophasianus*) in recent decades have been attributed to a number of land-uses, including grazing because herbaceous cover is important for sage-grouse nesting and brood rearing. However, sage-grouse population response to grazing management has yet to be evaluated across large spatial extents. The Bureau of Land Management (BLM) currently oversees grazing on nearly 250,000 km^2 of sagebrush land, and their records provide a unique opportunity to assess the response of sage-grouse populations to rangeland management. We used grazing data collected by BLM from grazing allotments in the state of Wyoming to test response of sage-grouse to the timing and intensity of grazing, and interactions with vegetation productivity. We used annual counts of displaying males from 673 lek sites (2004-2014) and modeled population trends using state-space models in a Bayesian framework. We estimated a positive response to sagebrush cover, whereas effects from grazing timing and intensity varied with vegetation productivity. Among drier sites with low vegetation productivity, early grazing was compatible with sage-grouse populations but at lower intensities; higher intensity

grazing was permissible later in the growing season. Conversely, we found that late-season grazing among mesic sites, particularly at high intensities, had a negative effect on sage-grouse populations. While the exact mechanisms behind these trends remain to be tested at finer scales, our findings may inform future grazing management policies by BLM and other agencies, as well as on private lands.

LONG TERM SAGEBRUSH HABITAT MONITORING ACROSS WLCI, WHAT IS CHANGING AND WHAT DOES IT MEAN?

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The USGS has been conducting sagebrush and vegetation change monitoring in WLCI with field measurements every year since 2008, and with satellite remote sensing since1985. Remote sensing offers the opportunity to scale up field measurements and subsequently provide wall to wall WLCI vegetation monitoring. We quantified sagebrush habitat as components of bare ground, shrub, sagebrush, herbaceousness and litter. Once components were quantified using current satellite measurements, previous year satellite images from the Landsat archive were then quantified to understand historical trends. Analysis of imagery back to1985 shows components of bare ground and herbaceous increasing over time and sagebrush decreasing over time across the WLCI. We then applied a linear model to relate the historical trend of the component value for each pixel to the historical precipitation trend – and projected this into the future for the year 2050. This process provides a way to quantify the potential impact of future climate change on the quantity of sagebrush components. Results indicate that with projected 2050 precipitation amounts, sagebrush will continue to decline and bare ground to increase across WLCI. When 2050 quantities of change are translated to sage grouse habitat in a subset of WLCI, there is a projected loss of 4% of summer sage grouse habitat and 11% of nesting sage grouse habitat by climate change alone. Future work will provide more comprehensive analysis of potential climate change and sage grouse habitat effects. In addition, a major new USGS and BLM effort is underway to update sagebrush habitat components for all of Wyoming using 2015 satellite measurements. These products will also provide per-pixel estimates of bare ground, sagebrush, shrub, herbaceousness, annual herbaceousness, shrub height, and litter and are designed to provide a new base for future monitoring.

EFFECTS OF MOWING AND HERBICIDE TREATMENTS ON THE NUTRITIONAL QUALITY OF SAGEBRUSH IN CENTRAL, WYOMING

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Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) is the most widely distributed subspecies of big sagebrush and has been treated through chemical application, mechanical treatments, and prescribed burning to improve habitat conditions for species such as greater sage-grouse (*Centrocercus urophasianus*) and mule deer (*Odocoileus hemionus*). Although the response of structural attributes of sagebrush communities to treatments is well understood, there is a need to identify how sagebrush treatments influence the quality of winter food available for wildlife. The purpose of our research was to identify how mowing and herbicide treatments intended to reduce

sagebrush canopy cover influenced dietary quality of Wyoming big sagebrush in treated Wyoming big sagebrush communities in central Wyoming. Two study areas were mowed in January and February 2014 and herbicide was applied in two study areas in May 2014. We constructed six exclosures in each study area (24 total), which encompassed 30 m X 30 m areas of treated and untreated sagebrush within each exclosure. Samples of current annual growth were collected from 18 sagebrush plants from treatment sites and 12 plants from control sites within each exclosure during November 2013 and 2014. Samples were analyzed for crude protein and secondary metabolites known to influence dietary selection of sagebrush by sage-grouse and other species. Preliminary results suggest that mowing treatments may slightly increase nutrient concentrations directly after treatments without immediate changes in secondary metabolites. Assessing dietary quality during additional years following treatments and potential trade-offs with loss of biomass associated with treatments will allow us to determine the influence of sagebrush treatments on dietary quality for sage-grouse and other co-occurring wildlife.

INVESTIGATING SAGE-GROUSE POPULATION TRENDS AMID INTENSE ENERGY DEVELOPMENT IN NORTHEAST WYOMING

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Over the last 50 years sage-grouse populations have declined mostly due to habitat loss and fragmentation, which can be attributed in some part to energy development. Sage-grouse in northeast Wyoming subsist on a lower density of sagebrush and live with a higher density of energy development compared to birds elsewhere in Wyoming. When compared to other sage-grouse populations affected by energy development, there is a relatively dense population of sage-grouse in the central portion of the Powder River Basin in northeast Wyoming. To determine why this population of sage-grouse appears to persist despite intensive development we used spatial statistics within a geographic information system to examine the size and orientation of active sage-grouse leks and compared those to the location and timing of well development and associated surface disturbance. Using these same methods, we examined the pattern and location of undeveloped or open space around the active sage-grouse leks within the study area. The results and management implications of these ongoing analyses will be discussed. Results could impact well distribution around active leks or management practices in other regions and help balance the multiple uses that sagebrush habitats in Wyoming must sustain.

Session 7. Ungulate Migration, Migration Habitat, and the Green Wave

Migration is an important component of the ecology and life history of many wildlife populations in Wyoming and throughout the world. In this session, we explore how new technology is being used to better understand ungulate migratory behavior. We will also explore how technology is allowing research scientists and wildlife biologists to delineate ungulate migration habitat in a way that has never before been possible. Finally, we will explore the relationship between migration, migratory habitat and development in order to better understand this emerging science and how best to apply it in land use decision making.

THE WYOMING MIGRATION INITIATIVE: ADVANCING THE UNDERSTANDING AND CONSERVATION OF WYOMING'S UNGULATE MIGRATIONS

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Wyoming harbors vast, open landscapes still capable of supporting long-distance ungulate migrations. Herds of big game move across rugged landscapes up to 150 miles seasonally to find adequate forage. While this foraging strategy allows animals to exploit gradients in snowfall and forage productivity, it also requires that they cross multiple-use lands, some of which are changing rapidly. Consequently, ungulate migration as an ecological process is difficult to manage and conserve. Recent research has enhanced our understanding of both the benefits of migration and the consequences of land-use change. This talk will describe some of the most pressing challenges to the conservation of ungulate migration routes in Wyoming and the West. Most importantly, I will outline recent research indicating how the behavioral responses of migrating ungulates to disturbance, from energy and housing development, holds the potential to diminish the benefits of migration and lead to its loss across impacted landscapes. Incorporating new scientific information into the management and conservation of ungulate migrations is a daunting task. In 2012, we created the Wyoming Migration Initiative (WMI), whose mission is *To advance the understanding, appreciation, and conservation of Wyoming's migratory ungulates by conducting innovative research and sharing scientific information through public outreach*. I will conclude with a description of some of WMI's recent work and the new conservation tools that our bringing people, agencies, and NGOs together to make these journeys easier for migrating big game.

EVALUATING THE INFLUENCE OF DEVELOPMENT ON MULE DEER MIGRATIONS

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Impermeable barriers to migration have obvious and detrimental effects on migratory ungulate populations, but it is less clear how semipermeable barriers influence migratory behavior and population performance. We used GPS movement data to evaluate the influence of semipermeable barriers on several migration behaviors of mule deer (*Odocoileus hemionus*) in southwestern Wyoming, USA. We analyzed data collected from three study areas characterized by different disturbance types: energy (n = 163 deer), suburban housing (n = 121), and low intensity rural

development (*n* = 108). We used linear mixed modeling and regression analysis to evaluate the influence of development on movement rate, stopover use and route fidelity. For each collared deer in each season and year, we selected paired segments representing intact and developed locations along the route. Deer avoided development when selecting stopover areas and spent 35% less time in stopovers influenced by disturbance overall, and 64% less in the most highly disturbed energy development area. Fidelity to migration routes (99% utilization distribution) was not influenced by development, as measured by the degree of spatial overlap between seasons and years, though fidelity to stopovers was reduced with rapid and high development. Our work indicates that deer modify behaviors - including speeding up, stopping over less and shifting the location of stopovers during migration - in developed portions of the routes. These findings indicate that development in migration routes will alter the migratory behavior of mule deer, with the clear potential to diminish the foraging benefit of migration and facilitate the long-term decline of migratory populations.

NUTRITIONAL RELATIONSHIPS BETWEEN MULE DEER BEHAVIOR AND HUMAN DISTURBANCE

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For North American ungulates, availability of resources on winter ranges often is limited in quality and abundance; consequently, individuals often rely on somatic-energy reserves (i.e., fat and protein) during winter to promote reproduction and survival. Encroachment of human disturbance onto winter ranges may further exacerbate the nutritional bottleneck by prompting avoidance of otherwise available habitat and altering foraging behavior. Although behavioral responses to human disturbance affect population dynamics, the proximate mechanisms that underpin these effects are difficult to identify. We hypothesized that behavioral responses to human disturbance that directly affect nutritional condition is the pathway by which human disturbance may influence ungulate populations. To test this hypothesis, we evaluated winter habitat condition, browse use by herbivores, and seasonal change in nutritional condition (i.e., % body fat) of 148 female mule deer (*Odocoileus hemionus*) equipped with GPS collars across three discrete winter ranges that varied in intensity of human disturbance from energy development. We used these data to explore the relationships among behavior, nutritional condition, winter habitat conditions, and exposure to human disturbance. Use of available browse was affected most by proximity to energy development and annual production of browse, but browse use decreased closer to development. Furthermore, deer that resided near development had increased movement rates, and in turn, movement rates negatively affected nutritional condition. Our results indicate mule deer on winter ranges exposed to human disturbance alter behavior in a way that can negatively affect nutritional condition, thereby potentially revealing the link between human disturbance and the ensuing effects on population dynamics.

DOES DROUGHT AFFECT THE ABILITY OF MIGRATORY MULE DEER TO SURF THE GREEN WAVE?

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Migration is a strategy that allows herbivores to exploit high-quality resources available on one seasonal range, while avoiding resource deficiencies on the other. Increasingly, research suggests that the migratory route is a critical habitat, and not merely a means to connect seasonal ranges. The Green Wave Hypothesis predicts that migratory ungulates access young, highly nutritious forage while moving along the leading edge of the spring green-up, i.e., the green wave. This hypothesis has seen limited evaluation, and yet is central to understanding the consequences of climate-induced phenological changes for migratory ungulates. We tested the Green Wave Hypothesis by evaluating the match between plant phenology and spring movements (i.e., surfing) of migratory mule deer (*Odocoileus hemionus*) in western Wyoming. We also investigated the influence of drought on patterns of green-up and the subsequent influence on the ability of deer to surf the green wave. We quantified plant phenology along migratory routes by calculating the instantaneous rate of green-up (IRG) from annual curves of the Normalized Difference Vegetation Index (NDVI, MODIS 250m). In support of the Green Wave Hypothesis, date of optimal IRG and the date of deer occupation during migration was positively related (n=1216 locations, r^2=0.53, P<0.001). Individuals (n=38) varied in their ability to surf the green wave: 42% following it closely, 55% tracked behind the green wave, and 2% deer tracked ahead of the green wave. Based on annual time series of NDVI, duration of green-up decreased with increased drought severity (Palmer modified drought index, r^2=0.44, P=0.004), increased temperature (r^2=0.24, P=0.06), and earlier loss of snow cover (r^2=0.34, P=0.02). Our work indicates that mule deer surf the green wave while migrating, but continued drought is likely to reduce the foraging benefit of migration by shortening the duration of spring green-up along migration routes.

STRAIGHT FROM THE MULE DEER'S MOUTH: USING BOTH SATELLITE DATA AND DEER MIGRATION LOCATIONS TO EXPLORE TEMPORAL AND SPATIAL TRENDS IN LANDSCAPE VEGETATION PRODUCTIVITY

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Climate change models for the northern Rocky Mountains predict warming and changes in water availability that may alter vegetation. Changes to vegetation may include timing of plant life-history events, or phenology, such as green-up, flowering, and senescence. These changes could make forage available earlier in the growing season, but shifts in phenology may also result in earlier senescence (die-off or dormancy) and changes in overall production. Measures of plant photosynthesis, such as the normalized difference vegetation index (NDVI), are regularly used to quantify plant growth and health over large areas using remotely sensed reflectance data. Such remote-sensing vegetation indices (VI) are often used as a spatial and temporal indicator of productivity and habitat quality, but an additional indicator of habitat quality is animal use. In this work we use stopover areas – where mule deer linger during their spring migrations – as hypothesized vegetation productivity "hotspots" on the landscape – areas that are more productive relative to their surroundings as indicated by VIs. We compared the VI characteristics of a subset of stopover polygons to an adjacent area and to a non-adjacent area with the same vegetation cover classification on the migration route. Comparisons were made twice: the relatively wet year of 2014 and the relatively dry year of 2013. Fitness (body fat and reproductive status) of the individual deer identifying the sampled stopovers was noted for each year. Coupling animal use and fitness with greenness information provides additional insight into habitat quality of stopover areas. Detailed understanding of spatial and temporal use of the landscape may allow more long-term, strategic surface management.

THE EXTRA MILE: UNGULATE MIGRATION DISTANCE ALTERS USE OF SEASONAL RANGE AND EXPOSURE TO ANTHROPOGENIC RISK

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Partial migration occurs across a variety of taxa and has important ecological and evolutionary consequences. Among ungulates, studies of partially migratory populations have allowed researchers to compare and contrast performance metrics of migrants versus residents and examine how environmental factors influence the relative abundance of each. Such studies tend to characterize animals discretely as either migratory or resident, but we suggest that variable migration distances within migratory subpopulations may represent an important and overlooked form of population structure, with potential consequences for animal fitness. We examined whether the variation of individual migration distances (20 to 264 km) within a single mule deer

(*Odocoileus hemionus*) population was associated with several critical behavioral attributes of migration including the timing of migration, time allocation to seasonal ranges, and exposure to anthropogenic mortality risks. We found that migration distance influenced both the timing of migration and the amount of time animals allocated to seasonal ranges. Animals migrating long distances (150 to 250 km) initiated spring migration more than 30 days before those migrating moderate (50 to 150 km) or short distances (< 50 km). Long-distance migrants spent approximately 100 more days migrating compared to moderate and short-distance migrants. Relatedly, the winter residency of long-distance migrants was 70 days less than animals migrating shorter distances. We also found that anthropogenic mortality factors, including highways, fences, and harvest vulnerability varied strongly with migration distance. Clear differences in winter residency, migration duration, and levels of anthropogenic mortality risk among the short, moderate, and long-distance migrants suggests distinct fitness tradeoffs among the migratory segment of the population. By reducing the amount of time that animals spend on winter range, long-distance migration may alleviate intraspecific competition for limited forage supplies and effectively increase carrying capacity of the larger population.

DO LARGE HERBIVORES SURF NDVI-BASED RATE OF GREEN-UP?

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The Green Wave Hypothesis (GWH) states that migrating animals should track or "surf" the leading edge of spring green-up where forage quality is highest. To index such peaks in forage quality, recent work has proposed the instantaneous rate of green-up (IRG) or change in the Normalized Difference Vegetation Index (NDVI) curve over time. Despite this advancement, no study has tested the assumption that herbivores select habitat patches at peak IRG in accordance with the GWH. We evaluated this assumption using Step Selection Functions parameterized with movement data during the green-up period from two populations each of bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), moose (*Alces alces*), and bison (*Bison bison*), totaling 463 individuals monitored 1–3 years between 2004 and 2014. After accounting for habitat attributes that typically influence selection by each species, seven of the 10 populations selected habitat patches exhibiting high IRG. Elk and deer tended to select habitat patches at the trailing edge of the IRG wave, whereas all others except for a single bison population selected habitat patches at the crest of the IRG wave. In support of the GWH, the majority of the populations surfed a green wave of high quality forage in spring as indexed by IRG. Our finding that not all populations surf at the crest of the IRG wave indicates that there may be other constraints to optimal surfing not captured by remotely sensed data. Nonetheless, it appears that the NDVI-derived IRG provides a new framework for understanding and predicting animal migration and movement across species and study areas. Most importantly, the IRG metric now allows wildlife biologists, researchers, and managers to assess how habitat quality changes over time throughout the growing season, a dynamic that is becoming increasingly important in the era of global climate change.

PRIORITIZING CONSERVATION VIA PREDICTIVE MODELING OF MIGRATORY HABITAT

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Migratory animals face an increasingly uncertain future as migration routes are severed or threatened by anthropogenic influences, persistent and wide-ranging drought alters vegetation communities, and population trends edge downward. Research and conservation efforts in recent years have focused on understanding the importance of specific habitats, such as stopovers or bottlenecks. To conserve migration routes in their entirety, as opposed to specific sections of some migration corridors, an understanding of where migrations occur at the landscape-scale is necessary. To bridge the gap between current local knowledge of migration habitat and corridors gleaned from intensive GPS collaring efforts, we developed a machine learning model to predict migratory areas for mule deer throughout the state of Wyoming. We used landscape variables, including topographic metrics and plant phenology metrics, which have been shown to be important in previous migration research. The model was highly accurate in predicting migratory habitat, matching known migratory data more than 85% of the time. Although the resulting prediction surface does not allow a complete understanding of factors influencing habitat selection in migration corridors, a statewide prediction of areas that are more or less likely to be migratory habitat for mule deer will aid in targeting conservation measures and conserving migration routes and migratory populations. Our methodology to analyze and predict migration habitat across vast landscapes allows migratory habitats to be mapped range-wide where sufficient location data exists; although our model focuses on mule deer, the same concept and model could be easily applied to other taxa. Conservation efforts for declining mule deer populations can benefit from these methods by identifying key areas to focus attention and areas where future research should be conducted.

Poster Abstracts

(Presenting author underlined, student presentations noted with an asterisk)

BIOFILM RESPONSE TO HEAVY METAL TOXICITY: A POTENTIAL BIOMARKER OF RIVER HEALTH

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Microbial biofilms comprise the greenish-brown slime that is attached to rocks, plants or other surfaces in rivers. Metal contamination from mining effluent can modify the biofilm community structure, diversity, and activity. The biofilm response to metal toxicity can be quantitatively measured at a low cost with recent advances in high-throughput DNA sequencing technology. We have used this technology to identify the biofilm community at 11 historically monitored sites in a designated superfund site in the Clark Fork Basin, Montana. The bacterial genus *Lysobacter* was identified as a potential biomarker of metal contamination by integrating the geochemistry at the sites with the biofilm community results. Monitoring metal toxicity in rivers has been difficult because complex biogeochemical processes and variable flow conditions can mask direct relations between metal concentrations and toxicity. Biofilms could be an effective biomarker of metal toxicity because that are resistant to changes in flow, rapidly respond to environmental perturbation, and play an important role determining metal mobility. The identification of a predictable biofilm response to heavy metal contamination could provide an effective tool to monitor the estimated 20,000 to 50,000 mine sites that contribute to heavy metal contamination and threaten many rivers in the western United States.

BOREAL TOAD HABITAT SELECTION AND SURVIVAL IN RELATION TO GRAZING INTENSITY AND DISEASE PREVALENCE

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In recent decades, many amphibian populations have declined worldwide. Human-induced habitat disturbance and alteration have been cited as a dominate causes, which can interact with other stressors such as climate change and disease. In the majority of cases, however, mechanisms underlying declines are considered enigmatic; therefore, developing a better understanding of the individual and interactive factors threating amphibians will be critical to prevent further population declines and species extinctions. To investigate the possible effects of multiple stressors on amphibians, we will assess how livestock grazing individually and in conjunction with disease may affect boreal toad (*Anaxyrus boreas*) movement, habitat selection, and survival in the Bridger-Teton National Forest in western Wyoming. In 2015, we used radio-telemetry to study the summer movements and habitat use of 61 adult boreal toads (40 male and 21 female) across sites varying in grazing intensity. Additionally, we swabbed individuals for disease and inserted passive integrated transponder (PIT) tags into 302 adult toads. We will analyze habitat selection at the micro- and macro-scales by comparing sites used by radio-tracked toads with paired and randomly selected

sites. In 2016 and 2017, we will conduct recapture surveys to evaluate toad survival rates. We will also test swab samples for *Batrachochytrium dendrobatidis* (*Bd*) to evaluate disease status of boreal toads across several drainages. Findings from this study will provide valuable information to several agencies working to improve management of toad populations in Wyoming. More broadly, by assessing how multiple stressors may interact to influence amphibian behavior, ecology, and habitat quality, our study design may provide a framework for future research evaluating causative factors in amphibian declines.

FINDING THE BALANCE: LANDSCAPE MANAGEMENT FOR MULTIPLE BIRD GUILDS IN THUNDER BASIN GRASSLANDS, WYOMING

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Management for one or a few focal species is a common practice, but this technique is not adequate in complex landscapes with diverse animal communities. The Thunder Basin National Grasslands (TBNG) of northeastern Wyoming are composed of a heterogeneous mosaic of sagebrush (*Artemisia* spp.), short-grass, and mixed-grass plant communities. Portions of TBNG have been designated as core area for greater sage-grouse (*Centrocercus urophasianus*); these areas are important for the conservation of this Wyoming Species of Greatest Conservation Need (SGCN), as well as other sagebrush obligate birds. The grasslands also support one of the largest complexes of black-tailed prairie dogs (*Cynomys ludovicianus*) in North America, and have been prioritized as a reintroduction zone for the endangered black-footed ferret (*Mustela nigripes*). These shortgrass prairie dog colonies also provide critical breeding habitat for the mountain plover (*Charadrius montanus*), a Wyoming SGCN, and USFS Species of Conservation Concern. Conservation of these diverse species in the same landscape requires spatial optimization of management approaches and a better understanding of spatial tradeoffs. With this in mind, we initiated a pilot study in summer 2015 to examine how shortgrass, mixed-grass, and sagebrush obligate bird species are influenced by the composition and spatial configuration of habitat patches in the Thunder Basin landscape. We surveyed birds on transects placed across sage grouse leks ("sagebrush," n=10), prairie dog colonies ("shortgrass," n = 10), and also across edges between colonies and adjacent habitat ("edge," n = 41). We will use data collected over the next three years (2016–2018) to generate models of single species density as a function of local and landscape habitat variables. Based on these models, we will identify optimal habitat configurations of colonies and sagebrush to maximize habitat availability for both sagebrush and grassland birds in the Thunder Basin landscape.

COMPARING EFFICACY OF EDNA VS. VISUAL SURVEYS FOR AMPHIBIAN MONITORING

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Many amphibians in the Medicine Bow-Routt National Forest (MBR) are state Species of Concern/Greatest Conservation Need, partly due to lack of information, in part because of low detection rates. Using eDNA to establish amphibian presence could: increase accuracy and decrease costs of surveys, increase the number of sites sampled per unit effort, refine distribution and

extinction records, and provide early detection of invasive species without any risk to the local ecosystem. Quality presence/absence data responsibly inform effective management decisions, a critical factor in this era of dwindling resources. To determine whether and in what circumstances molecular surveys can augment efficiency of amphibian monitoring and detection, we will: 1) Develop and troubleshoot molecular markers (quantitative PCR) for all five local amphibian species (4/5 currently developed-*Lithobates sylvaticus* excepting), 2) compare estimated rates of detection and occupancy by species for each method 3) use estimated detection rates to conduct cost/benefit analyses, and 4) determine eDNA's ability to reliably identify amphibian breeding sites. In summer 2015, we implemented eDNA based survey efforts into an existing long term amphibian monitoring effort in the MBR using 20 wetland catchments stratified by elevation and known species presence. This will allow effective occupancy modeling to establish molecular efficiency of detection probability, species rarity, etc. Collected naïve detection rates are as follows: *Psuedacris maculata* (.383), *Ambystoma mavortium* (.092), *Anaxyrus boreas* (.067), *Lithobates pipiens* (.042), and *Lithobates sylvaticus* (.133). Based on previous, similar work indicating up to two-fold detection improvements, we expect to find marked increases for more cryptic species like *A. mavortium*, *A. boreas*, and *L. sylvaticus*.

HABITAT USE, PREDATION RISK, AND RESOURCE AVALIBALITY: FITNESS TRADE-OFFS IN AN ISLAND ENDEMIC, THE ISLAND SCRUB-JAY

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The leading cause of reproductive failure for most passerine birds is nest predation. Because nest predation can strongly limit fitness, selection should favor birds that are able to assess predator communities within their home range and adjust nest sites accordingly. We are investigating the mechanisms that drive nest site selection and nest success in the Island Scrub-Jay by 1) comparing nest sites to paired non-use, but available nest sites, 2) identifying important nest predator species, and 3) quantifying reproductive investment, nest survival, and the abundance of main nest predators (Common Ravens (*Corvus corax*) and Island Foxes (*Urocyon littoralis*) across 2 habitat types, Bishop Pine woodland and Oak Chaparral. Between February 10 and June 15 2015 we located and monitored 105 nests through fledge or fail and conducted microhabitat analyses on each. We deployed 24 hour infrared bullet cameras at a subset of nests to capture predation events. We used distance sampling of fox scat along transects and raven point counts from a single high visibility location on each plot to estimate a relative index of predator activity. Preliminary results suggest a relatively low number of nest attempts and smaller clutch sizes in the pines suggesting that pine habitat is suboptimal for breeding. However, both the Common Raven and the Island Fox were detected in lower numbers and nest success rates were higher in the pines. This suggests that despite lower food availability, there was lower nest predation pressure in the pines, offering survival benefits to pine residents. Our work in this system has broader implications in terms of understanding habitat choices in different ecological contexts and fitness trade-offs of selecting habitats with contrasting resource availability such as food and refugia from predation.

UNDERSTANDING THE ARCHITECTURE OF OVERWINTER FOOD CACHES IN A MONTANE MAMMAL

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Food caching, the storage of food for future use, is a strategy many animals use to combat times of reduced food availability. In many cases, caches provide critical reserves that allow animals to persist in environments where food is lacking or absent during much of the year. Careful arrangement of food within stores may further facilitate physical integrity of the cache, improve food preservation, or ensure that cached resources meet future nutritional demands. Although many studies have addressed food caching as a strategy, no published studies have examined whether a systematic arrangement exists within individual food stores. The American pika (*Ochotona princeps*), a food caching, montane mammal, is an ideal study organism for evaluating the extent to which animals organize and structure caches. We evaluated variation in cache structure by addressing four hypotheses regarding the number of caches per individual, relative age (adult or juvenile), cache volume, and available vegetation. We defined structure as the presence of horizontal layers composed of homogeneous plant functional groups. We identified homogeneous layers using a modified line-intercept method. Thirty-six percent of the 55 caches sampled showed evidence of within-cache layering at the level of plant functional groups. Subsequent analyses will consider the degree to which the distance to nearest vegetation, diversity in available vegetation, number of haypiles per individual, individual stage (juvenile/adult), and haypile volume influence haypile structure. Understanding the extent to which animals organize over-winter reserves will provide insight to the range of food-caching strategies employed in variable environments. This understanding may provide a platform from which future researchers can explore the relationship between cache structure and individual fitness.

INFLUENCE OF BARK BEETLE EPIDEMIC ON ELK AND HUNTER MOVEMENTS AND INTERACTIONS

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For large ungulates, factors such as nutrition, energetics, and hiding and thermal cover all influence resource selection. For nearly two decades, the forests of the Rocky Mountains (USA) have been experiencing a bark beetle epidemic of severity and duration that has not been seen in over a 100 years. Between northern Colorado and southern Wyoming, the mountain pine beetle (*Dendoctronus ponderosae*) alone has caused mortalities in over 1.5 million hectares of lodgepole pine (*Pinus contorta*) forest. As the epidemic changes the structure and characteristics of the forest, the ungulates that inhabit these areas may alter their resource selection patterns to adapt to changing habitats. Moreover, ungulate distributional shifts may also lead to changes in the hunting patterns of humans, which are the primary predator of adult ungulates in affected forests. We are evaluating how the resource selection of elk (*Cervus elaphus*) is being influenced by the bark beetle epidemic in the Sierra Madre Mountains of southeast Wyoming. By employing global positioning system (GPS) technology to document the movements of elk, we are quantifying how elk move about a forest with increased downed trees and understory vegetation and a potential reduction of thermal

and hiding cover. Specifically, we will use a satellite–derived land classification to develop resource selection functions for elk to examine resource selection during various stages of beetle killed forests. In addition, we are coupling our analysis of elk resource selection with an analysis of how beetle kill is influencing hunter movements and interactions with elk. This work is done through voluntary monitoring of hunter movement paths during the fall hunting season. Our work will provide novel insights into how the bark beetle epidemic will influence elk resource selection and hunter effort, and this information will inform wildlife and land management decisions regarding ungulates and hunting in beetle killed forests.

RESPONSE OF GREATER SAGE-GROUSE TO HABITAT TREATMENTS IN WYOMING BIG SAGEBRUSH

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Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) has been historically treated through chemical application, mechanical treatments, and prescribed burning to increase amount and quality of herbaceous forage. Treatments are generally intended to rejuvenate sagebrush stands by killing older sagebrush plants to promote growth of younger sagebrush plants and increase resources for herbaceous production. However, information regarding greater sage-grouse (*Centrocercus urophasianus*) response to treatments is limited. Identification of specific habitat treatments that promote positive, negative, or neutral sage-grouse demographic response is necessary to evaluate the utility of sagebrush habitat treatments for sage-grouse and other co-occurring wildlife species. Our Before-After Impact-Control study began in the spring of 2011. Pre-treatment data collection continued through 2013 until mowing and Spike 20P treatments were applied in the winter and spring of 2014, respectively. Post-treatment data collection began in spring 2014 and will include up to 5 years. Our study is primarily designed to evaluate sage-grouse nesting success, brood survival, and adult female survival in response to mowing and herbicide treatments in central Wyoming. In addition, we are also evaluating: 1) nutritional quality of treated Wyoming big sagebrush, 2) dietary resources used by chick sage-grouse in treated and untreated areas, and 3) habitat selection patterns of grouse exposed to treatments. Our study uses data collected from approximately 100 radio-marked female sage-grouse that use 6 study areas each year. There are 2 study areas each that were mowed, aerially applied with Spike 20P, or serve as untreated controls. In our poster, we report preliminary findings associated with habitat selection and demographic responses from 2011 through 2015.

GROUNDWATER AND GEOHYDROLOGY OF THE LOWER TERTIARY AQUIFER SYSTEM, NORTHERN GREEN RIVER BASIN, WYOMING

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In cooperation with the Bureau of Land Management, groundwater levels in wells located in the northern Green River Basin in Wyoming, an area of ongoing energy development, were measured by the U.S. Geological Survey from 2010 to 2014. The wells were completed in the uppermost aquifers of the Green River Basin lower Tertiary aquifer system, which is a complex regional aquifer system that provides water to most wells in the area. Drilled depth of the wells was observed as a useful indicator of depth to groundwater such that deeper wells typically had a greater depth to groundwater. Comparison of a subset of wells included in this study that had historical groundwater levels that were measured during the 1960s and 1970s and again between 2012 and 2014 indicated

that, overall, most of the wells showed a net decline in groundwater levels. The groundwater-level measurements were used to construct a generalized potentiometric- surface map of the Green River Basin lower Tertiary aquifer system. Groundwater-level altitudes measured in nonflowing and flowing wells used to construct the potentiometric-surface map ranged from 6,451 to 7,307 feet (excluding four unmeasured flowing wells used for contour construction purposes). The potentiometric-surface map indicates that groundwater in the study area generally moves from north to south, but this pattern of flow is altered locally by groundwater divides, groundwater discharge to the Green River, and possibly to a tributary river (Big Sandy River) and two reservoirs (Fontenelle and Big Sandy Reservoirs).

MECHANISMS UNDERLYING INCREASED SONGBIRD NEST PREDATION RATES WITH NATURAL GAS DEVELOPMENT

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Energy development has become a primary source of anthropogenic habitat alteration in the western US, with the majority of development occurring within sagebrush dominated landscapes. Previous research in the Upper Green River Basin, WY demonstrated decreased daily nest survival rates of the three sagebrush-obligate songbird species (Brewer's sparrow, sagebrush sparrow and sage thrasher) with increased surrounding habitat loss due to natural gas development. This decreased nest success was due to increased predation, with three quarters of observed nest depredation events attributed to rodents. The objectives of our current study are to identify the relationship between songbird nest predation rates and small mammal abundance, and examine possible mechanisms driving the increased abundance of rodent nest predators. We are testing two main hypotheses to assess increases in rodent abundance surrounding natural gas development: 1) a mesopredator release hypothesis and 2) a food augmentation hypothesis. Data collection occurred from May-August 2015, and will continue in 2016. Nest monitoring, small mammal trapping, and mesopredator surveys were conducted across a gradient of habitat loss to address our first hypothesis, that predators for which rodents are a primary prey item may be less abundant near energy development. To address our second hypothesis, we assayed body condition of captured small mammals to assess whether reclaimed areas near well pads, which are primarily composed of native and non-native grasses and forbs rather than sagebrush, are providing supplemental food to rodents. Preliminary data suggest that songbird nest survival decreased with surrounding habitat loss, small mammals (deer mice and chipmunks) are consistently the main nest predators, and small mammal abundance was inversely related to nest survival. Identifying the drivers of nest predation in this system will improve understanding of how anthropogenic habitat change via energy development is affecting wildlife species of concern.

PICTURE THIS: MONITORING MIGRATORY ELK HERDS USING REMOTE PHOTOGRAPHY

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Population estimates of big games species are essential for biologists to manage productive herds while still maintaining annual hunter harvests. Many state agencies conduct herd composition surveys via helicopter or fixed wing aircraft, which are both costly and potentially dangerous to the biologists involved. Further complicating the estimation of herd productivity is the aggregation of migratory and resident herds on seasonal habitats. Several migratory elk (*Cervus elaphus*) herds in northwestern Wyoming share winter habitat with resident herds, making it difficult to attain herd-specific composition data. To gather composition data pertaining to each of these herds separately, and to better understand patterns in the timing of migration, we deployed remote trail cameras at geographic 'bottlenecks' to monitor migrating elk herds. Bottlenecks were identified with fine temporal scale GPS collar data in isolated regions were several migration routes overlapped. A total of 29 and 32 trail cameras were deployed at potential monitoring sites in the fall of 2014 and 2015 respectively. Cameras were left in place throughout the winter and spring months to capture both seasonal migrations. Although our results are preliminary, the camera data allow for several useful comparisons, namely i) variation in peak migration timing between herds, ii) the timing of fall migration for bulls versus cows, and iii) indices of calf survival. The duration of the peak fall migration varied with geographic region, ranging from two to five weeks. The duration of peak spring migration ranged from two to four weeks across regions. The majority of adult bulls migrated with the earliest groups in spring and up to two weeks later than cow and calf groups in the fall. We were not able to assess overwinter calf survival due to difficulty classifying yearling elk; however, summer survival rates were approximated, showing a general decrease in calf survival from spring to fall. Successful camera locations have potential to be used as a long term monitoring network where migratory herds can be predictably photographed year after year. Long-term data on compositional trends and timing of spring and fall migrations, will aid in developing herd management objectives and reduce annual survey costs.

CLARIFYING THE DISTRIBUTION AND HABITAT USE OF SMALL MAMMAL SPECIES OF GREATEST CONSERVATION NEED IN WYOMING

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Little is known about the role habitat plays in structuring small mammal communities of the high intermountain basins of the Rocky Mountains, particularly as they relate to small mammal species that are rare and considered poor competitors. Further, development of energy resources has grown at increasing rates over the last few decades. Considering global and national demand for energy resources, it is likely that development will continue to expand throughout the American and Canadian West. Due to the risk of energy development there is a need to better define distribution and habitat use of small mammal species that are rare and difficult to detect. The first goal is to create repeatable small mammal survey protocols designed to optimize the detection of rare and difficult to detect species, such as pocket mice, when they co-occur with abundant competitors, such as deer mice. The second goal is to develop an occupancy-based monitoring plan for my target small mammal species, which will result in baseline occupancy estimates across Wyoming's basins and allow accurate evaluation of habitat associations that accounts for low detectability. The resulting data will be used to reassess the distribution and conservation status the target species. The third goal is to conduct habitat analysis based on survey data to clarify habitat associations of the target species in Wyoming. The expected result is improved habitat data for the sensitive and rare small mammal species surveyed in this project which may lead to more informed, effective

management decisions. Having a better understanding of the habitat requirement, niche partitioning, and occupancy of these small mammal communities will lead to more effective conservation of these rare species.

INORGANIC MINERAL RESOURCES IN THE WYOMING LANDSCAPE CONSERVATION INITIATIVE (WLCI) STUDY AREA

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Historically, mining was a major and diverse industry in southwestern Wyoming. In recent years only a few mineral resources (other than coal, which is an organic fuel resource, and therefore not included in this study) are actively being sought or exploited in the Wyoming Landscape Conservation Initiative (WLCI) study area. Over the past century there has been a significant shift away from small gold, copper, or iron mines. Today, hard rock mining is virtually non-existent in the study area, but other mineral extractions, such as for uranium and trona, are significant. A series of maps shows areas where mineral resources have been identified and, therefore, where there are likely to be past, present, or future impacts on the landscape due to mining activities. Base- and precious-metals, formerly the target of active mining, are no longer being produced. Most of these dormant deposits are in well-defined mineralized areas or mining districts. Iron remained an important commodity in Wyoming until recent decades. Uranium is being mined by in situ recovery in the northern part of Sweetwater County and additional uranium exploration and development projects have been proposed. Several non-metallic industrial minerals have been produced from the WLCI study area. Trona, mined for soda ash, is a significant commodity in Sweetwater County. Former phosphate mines (such as at Leefe and South Mountain) and prospects in the western part of the study area appear to have been either abandoned or reclaimed. Sand and gravel is being actively sought and produced from unconsolidated deposits; aggregate and crushed stone are produced from Paleozoic and younger sedimentary rock units. Other industrial commodities, such as dimension and building stone, gypsum, barite, clay, bentonite, helium, and sulfur are not included in this study.

NATIONAL BIOGEOGRAPHIC EFFORTS FOR REGIONAL SCIENCE AND MANAGEMENT

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There is a growing need for landscape-scale efforts to quantify, assess, and prioritize management of our nation's natural resources. The U.S. Geological Survey is working to integrate multiple biogeographic information resources (e.g. land cover, species distribution models, protected areas, threats) into a single national product to assist research and management of natural resources. To help ensure the success and utility of such efforts we are seeking interactions with and opportunities to learn from regional initiatives such as the WLCI and partner agencies to help refine our plans for synthesis and visualization. This poster displays biological information from the initial phases of the national efforts, placed into the context of WLCI goals and objectives, in hopes of encouraging feedback and suggestions to help direct future work.

SURVIVAL OF RED DESERT PRONGHORN IN THE FACE OF ENVIRONMENTAL AND ANTHROPOGENIC CHANGE

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Greater than 50% of the worldwide pronghorn population is found within the state of Wyoming, where the state-wide pronghorn population has declined by almost 35% from highs reached in 2007. Concurrently, Wyoming has experienced drastic changes in environmental conditions, particularly in the form of severe droughts and harsh winters, which have the potential to result in decreased survival rates. Nation-wide, Wyoming has also seen some of the greatest increases in energy production, particularly in natural gas. Impacts of infrastructure associated with energy development can affect wildlife by altering resource selection patterns and vital rates, and many recent conservation science and policy efforts are based on reducing these impacts to wildlife populations. Between November 2013 and 2014, we captured and equipped 186 adult female pronghorn with GPS or VHF transmitters to evaluate the influence of anthropogenic and environmental factors on demographic patterns across four sites impacted by varying levels of energy extraction in south-central Wyoming. The objectives of our survival study include assessing the individual effects of environmental and anthropogenic change on risk as well as the possible interactive effects of these potential stressors. We estimated survival rates using the Kaplan-Meier product limit estimator, modified for staggered entry. To model risk of survival, we used the Andersen-Gill formulation of the Cox Proportional Hazards model to assess survival as intervals of risk. Our work will increase knowledge of pronghorn demographic responses to increasing climatic variability and human presence on the landscape. As environmental conditions change and the demand for energy expands, our ability to separate and understand the influence of environmental change and resource extraction on pronghorn populations will be critical to guide efforts to manage and mitigate for their effects.

A NEW METHOD TO ASSESS LANDSCAPES FOR WILDLIFE: THE HABITAT RAPID ASSESSMENT

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Widespread acceptance of the importance of habitat in relation to wildlife population management is not a new concept. For decades, wildlife and habitat managers have attempted to manage one in concert with the other. However, increasing limitations on habitat and depressed wildlife populations relative to 30 years ago have forced managers to develop new tools to assess carrying capacity for the purpose of managing herds by objective. Opposed to the traditional model of monitoring several permanent locations over time, the authors developed standardized inventory methods to assess conditions of large-scale landscapes important to wildlife. These rapid assessments provide managers with understanding of how current habitat conditions function relative to big game population levels (i.e., population numbers are too high, balanced, or less than available habitat conditions). A secondary benefit of completing these assessments is the identification of areas suitable for management actions to benefit wildlife and overall watershed health. To date, assessments have been developed for shrub/rangeland, aspen, and riparian communities with plans to develop additional assessment for conifer and mountain herbaceous

communities in the next year. Additionally, the authors will work with population managers to integrate the assessment data into the objective review process in identified mule deer herds across the state.

USING DATA TO DELINEATE ELK SEASONAL RANGES: ACCOMPLISHING THE ELUSIVE RESEARCH-BASED MANAGEMENT

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State wildlife management agencies have a long history of determining and designating seasonal wildlife ranges. The accuracy of these ranges is important because they guide key management decisions such as seasonal area closures, development and disturbance restrictions, and research project study boundaries. Traditionally, seasonal wildlife ranges were delineated by local wildlife managers by hand-drawing polygons on maps based on their knowledge of animal use patterns in areas of their responsibility. In Wyoming, the Wildlife Observation System (WOS) has been used to supplement range delineations with observational data, however this dataset has drawbacks including road-bias, locations based on township and range sections, and inconsistent sampling effort. Since 2006, Wyoming Game and Fish's Brucellosis-Feedground-Habitat (BFH) group has worked with multiple collaborators to deploy over 400 GPS collars and almost 300 vaginal implant transmitters (VITs) on elk in western Wyoming. The primary objective of these efforts is to better understand elk behavior and disease ecology to reduce the incidence of *Brucella abortus* in elk and reduce the risk of disease spillover to livestock. However, with such a large quantity of precise location data amassed, we were in a unique position to update elk seasonal range delineations for the seven herd units where collars and VITs were deployed. We followed the Wyoming Chapter of The Wildlife Society's Standardized Definitions for Seasonal Wildlife Ranges, however we did deviate from these guidelines when defining parturition dates based on our data documenting live births and defining crucial winter range dates based on local expert knowledge. We applied a local convex hull model to the GPS data and a kernel density model to the WOS and VIT data, and allowed managers to manually edit the resulting ranges based on their local expertise. This effort is an excellent example of implementing research-based management and using research data for multiple purposes.

WYOMING GAME AND FISH DEPARTMENT AQUATIC HABITAT PROGRAM

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Personnel in the Wyoming Game and Fish Department's Aquatic Habitat Section work to protect and restore water and watersheds to conserve aquatic wildlife and their habitats for future generations. Aquatic habitat biologists implement restoration under a classic project cycle entailing assessment, design, implementation, and monitoring. Key principles and approaches include: planning and prioritizing under the Department's Strategic Habitat Plan (SHP), protecting the best first, working with natural processes, remembering to first "do no harm", following through by monitoring, and focusing on landscapes and connectivity. The poster describes the Aquatic Habitat Section program and provides project examples.

EFFECTS OF WILDFIRE SEVERITY ON UNGULATE FORAGE QUALITY AND HABITAT USE IN BRIDGER-TETON NATIONAL FOREST, WYOMING

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Studies typically show that the nutritional value of plants (i.e. percent crude protein, digestibility) increases following fire, yet burn severity is rarely considered. Climate change is predicted to increase the frequency and intensity of wildfires in the western United States. Therefore, we need to improve our understanding of how wildfire burn severity affects ungulate forage quality and habitat use. The 2011 Red Rock Fire, which burned over 9,000 acres in the Gros Ventre watershed in Bridger-Teton National Forest, presents a unique opportunity to monitor short and long-term changes in the nutritional content of ungulate forage based on burn severity. Percent crude protein and digestibility of forage are directly related to ungulate reproduction, lactation, and juvenile survival. There is currently little information on burn severity affects plant nutritional content over time. We mapped and sampled 57 sites exposed to low, moderate, and high severity burns, as well as areas that were unburned. We sample 12 plant species annually at these sites to track nutritional changes over time. We are interested in tracking both short (1-5 years) and long-term (5-10+ years) plant responses post-fire. We have collected three years of data and preliminary results show a marked increase in crude protein related to burn intensity. Elk were fitted with GPS collars prior to the fire; therefore, we monitored pre and post-fire habitat use and observed a 6% increase in elk use within the burn perimeter, particularly in the moderate and high burn severity areas. This is one of the first studies of its kind to monitor changes in ungulate habitat use and forage quality as they relate to wildfire burn severity over the short and long term.

WYOMING'S STATEWIDE FISH PASSAGE PROGRAM ON THE MOVE

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Wyoming waters provide ample fish habitat and great fishing, but Wyoming's waters are highly sought after for other uses too, for instance, cropland irrigation and irrigation for grazing. There are thousands of irrigation headgates registered within the state of Wyoming, many of which restrict upstream movement, entrain thousands of fish into irrigation canals, or both. Habitat connectivity is crucial for fish movement and is often inhibited by diversion dams. One part of Wyoming's fish passage program involves gathering evaluation data concerning irrigation headgates diverting water from the main water channel and diversion dams affecting upstream passage. The fish passage program has 1,174 point of diversions (POD) identified throughout the State. Within the Wyoming Landscape Conservation Initiative (WLCI) boundary there are at least 514 POD, 276 completed, 205 not completed and 33 POD that were given no access from the landowner. Collecting this data will help with the prioritization of future fish passage improvement projects.

IMPROVING THE GREEN RIVER RIPARIAN CORRIDOR BY CONTROLLING RUSSIAN OLIVE AND TAMARISK

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The Green River riparian corridor is a lush oasis in the vast sea of high desert sagebrush in southwest Wyoming. The Green River corridor provides many benefits to numerous aquatic and terrestrial wildlife species that depend on it for their life stage habitat needs. However, the riparian corridor is under attack from non-native species, namely Russian olive and Tamarisk (ROT). Since 2011, this attack has been thwarted by mechanical, chemical, and a combination of both methods. Collaborative efforts have focused multiple control treatments on the river corridor between Fontenelle Dam and the inflow area of Flaming Gorge Reservoir in order to promote landscape scale riparian system integrity and function. Cooperative partnerships between the Ashley National Forest, Boss Reclamation LCC, Bureau of Land Management, Bureau of Reclamation, City of Green River, Field Services and Weed Control LLC, private landowners, Seedskadee National Wildlife Refuge, Sweetwater County Recreation Board, Sweetwater County Weed and Pest District, Wyoming Game and Fish Department, Wyoming Governor's Big Game License Coalition, Wyoming Landscape Conservation Initiative, Wyoming Office of State Lands and Investments, and Wyoming Wildlife and Natural Resources Trust were instrumental in successfully controlling invasive ROT over the past 5 years. The initial project phase recruited partners to help with the control of the ROT. Then an assessment was completed by the Teton Science School to show where and how much ROT was on the landscape. The next phase was implementation; Sweetwater County Weed and Pest District and the City of Green River were crucial partners during this phase. The final phase is monitoring and maintenance; the City of Green River Schools is assisting with this phase. Removal of ROT within the Green River corridor is helping to sustain the system function of 37,700 acres of riparian habitat along a 72-mile reach of river.

Special Session: Effectiveness of Wyoming's Sage-Grouse Executive Order

The Wyoming Governor's Sage-Grouse Executive Order (SGEO) was implemented in 2008 by then Governor Dave Freudenthal as a policy to guide conservation policy for 82% of Wyoming's breeding population of greater sage-grouse in 31 core areas that encompass 24% of Wyoming's landscape. The SGEO was adopted by current Matt Mead, Wyoming's current governor in 2011. The SGEO was designed to thwart listing of the greater sage-grouse under the Endangered Species Act of 1973. As such, this broad conservation policy influences consideration of a broad spectrum of natural resource management activities within core areas, thus being of great interest to attendees of the 2015 joint conference of WY-TWS and WLCI.

Organizer & Moderator:

Jeff Beck, Department of Ecosystem Science and Management, UW Email: jlbeck@uwyo.edu

Panel Members:

- Pat O'Toole, Private Rancher
- Pam Murdock, BLM
- Mark Sattleberg, USFWS
- Mary Flanderka, WGFD/SGIT
- Joe Budd, WDA
- Garry Stephens, NRCS

Oral Presentations

THE THIRTY-THOUSAND FOOT VIEW: NUTS AND BOLTS OF THE WYOMING SAGE-GROUSE EXECUTIVE ORDER

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Former Governor Dave Freudenthal released an Executive Order in 2008 that created Wyoming's Sage-Grouse Core Area Strategy. The scientific basis for this strategy was an analysis of sage-grouse breeding density as well as the results of research assessing the impacts of anthropogenic activity to sage-grouse demographics and habitat use. The Governor's Sage-Grouse Implementation Team used the breeding density analysis as well as areas of existing or permitted anthropogenic activities to define the perimeters of the Core Areas. Core Area boundaries and executive order provisions were refined in 2010 under Freudenthal's direction and again in 2015 as directed by current Governor Matt Mead. Core Areas cover approximately 25% of the state and provide protection for 81% of male sage-grouse counted on leks as well as the nesting, brood-rearing and winter habitat associated with those leks. The Executive Order stipulates that while existing land use rights should be recognized and respected, new development within Core Areas should be authorized only when it can be shown that the activity will not cause declines in sage-grouse populations. The U. S. Fish and Wildlife Service's 2010 and 2015 listing decision documents supported Wyoming's Core Area Strategy as an effective regulatory mechanism if implemented as planned.

SGEO POLICY INFLUENCE ON SAGE-GROUSE CONSERVATION: ENERGY DEVELOPMENT AND MALE LEK COUNTS INSIDE AND OUTSIDE CORE AREAS

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Greater sage-grouse (*Centrocercus urophasianus*) populations have declined across their range due to human-assisted factors driving large-scale habitat change. In response, Wyoming's Executive Order for Sage-grouse (SGEO) implemented the Wyoming Sage-Grouse Core Area Protection policy in 2008 as a voluntary regulatory mechanism to minimize anthropogenic disturbance within defined sage-grouse core population areas. Our objectives were to evaluate the influence of the SGEO policy on: 1) oil and gas well pad development, and 2) peak male lek attendance in core and non-core sage-grouse populations. We conducted our evaluations at the statewide and Western Association of Fish and Wildlife Agencies management zone (MZ I and MZ II) scales. We used ANCOVA modeling to evaluate change in well pad development from 1986–2014 and peak male lek attendance from 958 leks with consistent lek counts within increasing (1996–2006) and decreasing (2006–2013) timeframes for core and non-core sage-grouse populations. Oil and gas well pad development was restricted in core areas. Trends in peak male sage-grouse lek attendance were greater in core areas compared to non-core areas at the statewide scale and in MZ II, but not in MZ I, during the period of increase. Trends in total male lek attendance did not differ between core and non-core population areas statewide, in MZ I, or MZ II during the period of decrease. Our results provide support for the effectiveness of the Wyoming SGEO policy in maintaining sage-grouse populations, but also indicate the need for restorative actions to increase sage-grouse populations in MZ I.

EFFECTIVENESS OF CORE AREA CONSERVATION METRICS FOR SAGE-GROUSE: CAN WE IDENTIFY DISTURBANCE THRESHOLDS ?

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The Wyoming Core Area policy for greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse) limits infrastructure development within areas of high sage-grouse population densities. Management of Core Areas mainly focuses on limiting surface disturbance as a proxy to regulate landscape change, regardless of type (e.g., natural gas, exurban development, prescribed fire). We are evaluating implications of the 5% surface disturbance maximum, the disturbance cap set by the Wyoming Core Area policy, on sage-grouse nest and brood productivity and sage-grouse female habitat use during these critical life-stages. Our analysis focuses on surface disturbance that have been quantified by explicitly following Density and Disturbance Calculation Tool (DDCT) methodology. To explore these relationships we are using nest locations (n = 1049) and brood-rearing locations (n = 2726; locations from VHF and GPS-marked females) compiled from 6 distinct study areas across Wyoming including Atlantic Rim and Stewart Creek (2008-2011), Southwest (2008-2011), Seven Mile Hill/Simpson Ridge (2009-2010), Jeffrey City (2011-2013), and Powder River Basin, Wyoming (2008-2011). Consequently, our sample of female sage-grouse were exposed to a variety of different landscapes and development types throughout Wyoming from natural gas (e.g., CBNG), conventional oil and gas development, wind farm development, to

landscapes with very little human habitat-alteration. We will be presenting preliminary results in regards to sage-grouse exposure to different levels of surface disturbance across different management scales both within and outside of sage-grouse Core Areas. Results will focus on habitat selection and productivity during the sage-grouse nesting period and relationships to exposure to different levels of surface disturbance and how these results relate to the 5% surface disturbance cap.

CORE AREA PROTECTIONS RELATIVE TO WINTER CONCENTRATION AREAS FOR GREATER SAGE-GROUSE

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Our studies aimed to delineate summer and winter concentration areas for greater sage-grouse (*Centrocercus urophasianus*; hereafter, sage-grouse), during 2008–2015. In our first study, we evaluated overlap of summer and winter concentration areas within 8 current Wyoming Sage-grouse Core Areas. To delineate seasonal concentration areas, we constructed kernel density contours (75% and 95%) using 7,692 summer and 1,488 winter sage-grouse locations from 5 distinct study areas. We compared the proportion of sage-grouse seasonal concentration areas that were within or outside of Core Areas. The proportion of summer concentration areas that overlapped with Core Areas was substantial with 0.69 of summer areas within a Core Area; whereas, 0.50 of winter concentration areas were within Core Areas. Ratios of individual summer to winter concentration area overlap indicated high variability (range of 0.94 to 3.67) in protection provided by Core Areas for winter concentration areas. In our second study, we used 44,000 winter locations obtained from 72 GPS-collared female sage-grouse across 2 study areas within 5 Core Areas to evaluate winter habitat selection. Resource selection functions indicated sage-grouse were selecting habitats in response to shrub characteristics, topography, and roads. Across studies, we found that generalizing winter habitat selection across study areas was inappropriate and selection should be assessed on a regional basis. Land use decisions used to construct Core Area boundaries resulted in removing some areas used by female sage-grouse in the winter from Core Area protection. The size and shape of constrained Core Areas relative to available sage-grouse breeding habitat in these areas resulted in more grouse locations falling outside Core Area protection during the breeding (15 Mar to 30 Jun) and winter (1 Dec to 15 Mar) seasons. This suggests seasonal use restrictions and other means to avoid impacts should be afforded to areas of winter concentration outside designated Core Areas.

USING CHANGES IN SAGE-GROUSE ABUNDANCE TO PREDICT LANDSCAPE HEALTH

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The increasing realization that large-scale patterns and processes influence the functioning of wildlife habitat, has led many researchers and conservation practitioners to set conservation targets that explicitly incorporate landscape-level metrics. However, landscape-scale conservation policy

presents a myriad of challenges for land managers. A science-based approach to conservation ensures transparency across stakeholders, quantification of effectiveness through rigorous monitoring, and adaptation of strategies depending on project outcomes and changing environmental conditions. An example of a species for which there is significant concern about its viability and commensurate conservation action is the Greater sagegrouse a species that ranges across sagebrush-steppe habitats of western North America including 11 U.S. states and 2 Canadian provinces. Concern for the long-term population viability of the species is due in part to continued contraction of their historical range and declining populations. We investigated sage-grouse trends using counts of males on leks from
2006 to 2013, and related these trends to landscape-scale changes in biological and anthropogenic variables across core areas in Wyoming. Annual estimates of male abundance were used to categorize the functionality of the landscape for sage-grouse through time according to predicted lek size and trend. We used the results of these investigations to evaluate spatial and temporal changes in the landscape-scale integrity of habitats designated as 'core' in
Wyoming. The process initiated here provides a framework for relating changes in landscape conditions to sage-grouse population abundance for iteratively assessing the efficacy of conservation actions.

PREDICTING HABITAT USE FOR GREATER SAGE-GROUSE USING A SPATIALLY-EXPLICIT DEMOGRAPHIC APPROACH IN WYOMING

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Identifying and prioritizing habitats that are important for conserving species is a challenging task, particularly for those with fluctuating populations and spatially and temporally differing habitat needs such as the greater sage-grouse (*Centrocercus urophasianus)* in Wyoming. To assess the long-term use of sage-grouse habitat and occupancy of core areas, we developed a spatially explicit individual-based model informed by lek counts, habitat selection maps, life history information, population dynamics, movement and behavior (i.e., nest site fidelities). Using a range of possible population trajectories, we quantified the contribution of areas inside and outside of protected core areas to population abundance. We also compared characterizations of important habitats generated from habitat selection (resource selection function) models with simulated habitat use influenced by population dynamics. Although the majority of birds occupy protected core areas during nesting, summer, and winter (up to 77, 77, and 71% respectively), occupancy depended in part on the season and population size, with a higher proportion of birds occupying cores during population downturns. When we simulated avoidance of areas outside of cores due to habitat loss and degradation, disproportionate population declines (up to ~ 45% of the population) indicated that non-core areas are likely to be important for accessing complementary habitats among seasons and locating and providing under-used habitats during population peaks. Explicit consideration of movement and population dynamics yielded habitat use predictions that emphasized the importance of high density, central, and accessible habitats that coincided or were near other seasonal habitats, particularly for summer and winter seasons. In contrast, habitat selection surfaces over-valued peripheral and isolated areas and those without overlap or linkages to other seasonal habitats. The addition of habitat selection, population dynamics and movement considerations may provide valuable insights into future assessments or prioritizations of important sage-grouse habitat, and should help with conservation and restoration planning.

Workshops:

Wyoming Chapter, The Wildlife Society - 2015 Leadership Training

Instructors:

- Tom Ryder, Past President, The Wildlife Society, Deputy Chief, Wildlife Division, WGFD (Retired)
- Nicole Cudworth, TWS Leadership Institute Graduate (2011), Wildlife Biologist, WGFD
- Tony Mong, TWS Leadership Institute Graduate (2011), Wildlife Biologist, WGFD

Initiated in 2006, The Wildlife Society's Leadership Institute (TWSLI) has become a valuable tool for training tomorrow's generation of TWS leaders and Wyoming is proud to have 6 graduates of this prestigious training. Graduates include Nick Kaczor and Sarah Bucklin in 2009, Martin Grenier in 2010, Nicole Cudworth and Tony Mong in 2011 and Jared Merkle in 2015. Instructors of this 4-hour workshop will present a condensed version of TWSLI, divided into 4, 1- hour segments. The first segment will discuss why strong leaders are necessary in the natural resources profession and outline success characteristics of previous conservation leaders. Segment two will delve into the basic principles of leadership. Participants will then be provided with techniques to develop a vision and personal leadership goals in segment three. This workshop will conclude with a discussion of why utilizing a team leadership approach is the most successful way to accomplish goals. Attendance will be restricted to 20 individuals and can include undergraduate and graduate students and early-career professionals (i.e., 5-7 years of experience).

Industry Biologists: Career Opportunities Working For and With Industry

Organizer:

Julie Lutz, Environmental Engineer Tronox Alkali

Numerous wildlife professions play non-traditional roles in Wyoming working for industry. These positions often guide and lead their company's efforts in balancing the need for the critical products and services their industry provides with the desire to protect and enhance wildlife populations and habitat. Often personnel in these roles have numerous opportunities to network and work collaboratively with other industry, governmental and non-governmental entities, other resource users, and public stakeholders on wildlife and environmental issues. These roles, responsibilities, and opportunities will be discussed. This panel will share experiences of biologists who's career path eventually lead them to satisfying and successful positions working for industry. Panelists represent the major industrial sectors in Wyoming, as well as wildlife consulting. Panelist have varied backgrounds, including past or present TWS membership, worked for government agencies, and/or serve(d) on statewide or regional boards, in addition to their industry careers. Panelists will share examples of collaborative projects they have participated in, as well as contributions they have made to wildlife management or conservation through their positions with industry. Conservation planning, reclamation, raptor protection and education, sensitive wildlife studies, and opportunity for collaboration with industry are some of the particular topics that will be covered by the participants. Panelists will share insights on the benefits to working for and with industry, and have satisfying careers in their positions. This workshop is designed to share information with other wildlife professionals, other agency personnel, and potential partners who may be unaware of these opportunities and potential collaborators.

Panelist:

- Julie Lutz, Environmental Engineer Tronox Alkali. She is the Wyoming Mining Association (WMA) Regulatory Affairs Committee Wildlife Subgroup Chair, and serves as the Mining Representative Southwest Local Working Group (Sage-grouse).
- Penny Bellah, Senior Regulatory analyst Sampson Resources. She serves on the Petroleum Association of Wyoming (PAW) Public Land Committee and Governor's Wyoming State Sage-grouse Implementation Team Member representing Oil & Gas.
- Sherry Liguori, Avian Program Manger, PacifiCorp (Rocky Mountain Power/Pacific Power). She is current Vice Chair of the Avian Power Line Interaction Committee and was the project manager and primary author of Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006.
- Josh Skorcz, Environmental Engineer Black Butte Coal Company. He has extensive experience in permitting and project design, reclamation, and construction.
- Nathan Wojcik, Ecologist SWCA Environmental Consultants. He has extensive experience in statistical data collection, habitat modeling, ecological restoration and conservation planning.

Communicating and Engaging Non-Scientific Audiences

Facilitators:

Joshua Coursey and Joey Faigl , Muley Fanatic Foundation

The purpose of this seminar is to look at the opportunities that can be exploited to engage new stakeholders in the conversation surrounding wildlife research and 21st Century conservation efforts. This segment will be facilitated by the Muley Fanatic Foundation, a 501 C (3) non-profit conservation organization that was established in 2012 by Joshua Coursey and Joey Faigl. Headquartered in Green River, Wyoming, MFF is the epitome of a grass roots effort that aims to ensure the conservation of mule deer and their habitat and to provide supporting services to further the sport of hunting and sound wildlife management.

To date MFF has put over 1 million dollars on the ground since its inception and one of the key cornerstones of MFF has been from the beginning to be a proactive proponent for obtaining the latest science available. "With a steady decline of mule deer over the last 20 years it is clear that we need to better understand the variables limiting mule deer numbers. There is no simple answer. An ever changing landscape with shrinking habitat, predators, development, drought, disease, competition and changes to migration movements are all having an impact on mule deer. It is our responsibility as a community to foster the necessary proponents to address these concerns. Collaborative efforts to bring new stakeholders to the table are critical in furthering such work.

Program R: a basic introduction (parts I and II)

Instructors:

Jason Carlisle, WY Cooperative Fish & Wildlife Research Unit, U. of Wyoming
Joe Ceradini, WY Cooperative Fish & Wildlife Research Unit, U. of Wyoming
Embere Hall, WY Cooperative Fish & Wildlife Research Unit, U. of Wyoming

Program R is a free software environment for statistical computing and graphics (http://www.r-project.org/), and R is increasingly popular among scientists across many disciplines including wildlife. R is notorious for having a steep learning curve, so we offer this 4-hour workshop (two, two-hour sessions across two days) to provide a very basic introduction to Program R and its uses, and to guide beginning R users through what may be their first encounter with R via RStudio, a program that makes the power of R more approachable (http://www.rstudio.com/).
Each participant must provide his/her own computer (with software-installation privileges), and instructions will be sent to participants in advance to download the free software used in the workshop. Example datasets and materials will be distributed at the workshop. Multiple assistant instructors will be on hand to assist with troubleshooting any issues that arise. We suggest attending both parts, but participants may choose to attend one day or the other. This workhop is designed for pre-beginner (those who may have never seen Program R) and beginner (those who may have dabbled lightly and would like to learn more) R users. Those users who are comfortable with R, but unfamiliar with RStudio, may also benefit. To help participants gain the basic skills needed to begin using Program R (with or without RStudio) and introduce resources for continued learning.

Part I	What R is (and is not)	Part II	Basic data summary
	Accessing R with RStudio		Basic plots
	Getting Data in/out of R		Basic statistics
	Basic data manipulation and management		Intro to resources for continued learning